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PROPOSED
2003 STATE AND FEDERAL STRATEGY FOR THE CALIFORNIA STATE IMPLEMENTATION PLAN

SECTION II

MOBILE SOURCES

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INTRODUCTION

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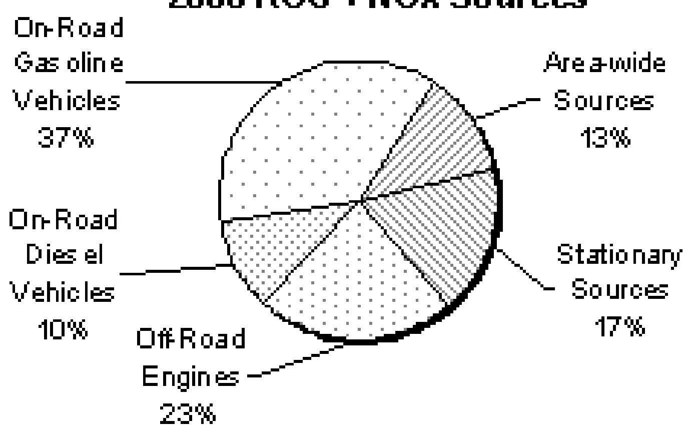
1. Category Description

Mobile sources encompass a broad variety of vehicles and equipment – everything from gasoline-fueled leaf blowers to large diesel-fueled ocean liners. Mobile source categories include: light- and medium-duty vehicles; heavy-duty vehicles; diesel equipment; gasoline equipment; and ships, planes, and trains. In addition, the gasoline or diesel fuel used in these vehicles, engines and equipment can have an impact on emissions.

On-road and off-road mobile sources account for about 70 percent of ozone precursor emissions in the State (Figure II-1). Reducing reactive organic gases (ROG) and oxides of nitrogen (NOx) emissions from on- and off-road mobile sources is a top Air Resources Board (ARB or "Board") priority because motor vehicles are the dominant source of air pollution and toxics health risk in California.

Figure II-1
2000 ROG + NOx Sources



To address California's acute air quality problems, the federal Clean Air Act granted California the unique authority to adopt and enforce rules to control mobile source emissions within California. ARB is required to adopt State requirements that are as stringent or more stringent than federal requirements. The California Clean Air Act requires ARB to achieve the maximum degree of emission reductions possible from vehicular and other mobile sources in order to attain the State ambient air quality standards by the earliest practicable date.

2. Existing Programs

California's mobile source and fuels programs exemplify the State's long-standing commitment to clean air. As far back as 1961, the State mandated the first automotive emissions control technology in the nation – the positive crankcase ventilation valve, or PCV valve, to control hydrocarbon crankcase emissions. Progressively tighter emission standards, coupled with fuel specifications, have put California in the forefront of mobile source emissions control.

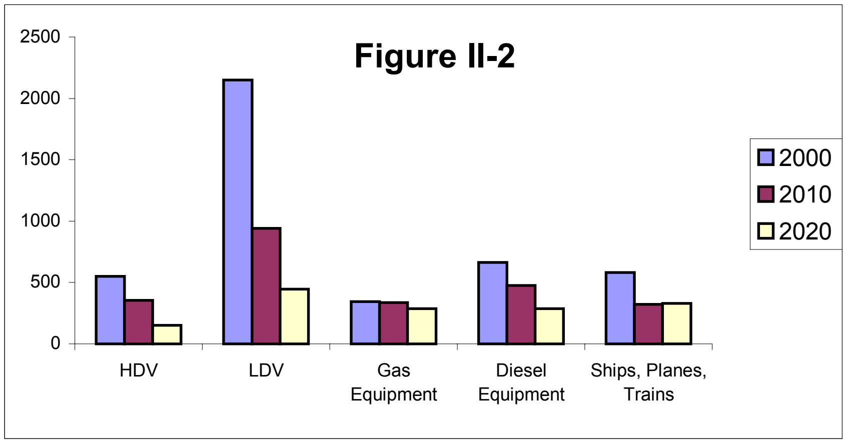
California has led the way in adopting stringent regulations for passenger vehicles. A new 1965 car produced about 2,000 pounds of smog-forming hydrocarbon emissions during 100,000 miles of driving. California's low-emission standards, coupled with reformulated gasoline, have cut that to less than 50 pounds for the average new car today. By 2010, California's standards will further reduce hydrocarbon emissions from the average new 2010 car to approximately 10 pounds.

Today, there are 24 million gasoline-powered vehicles registered in California, and over one million diesel-fueled vehicles and engines. To power these vehicles, over 14 billion gallons of gasoline and approximately 3 billion gallons of diesel fuel are consumed annually. To reduce the harmful effects of the emissions from all these vehicles, ARB has adopted fuel specifications that reduce exhaust and evaporative emissions from motor vehicles. These fuel initiatives complement mobile source controls.

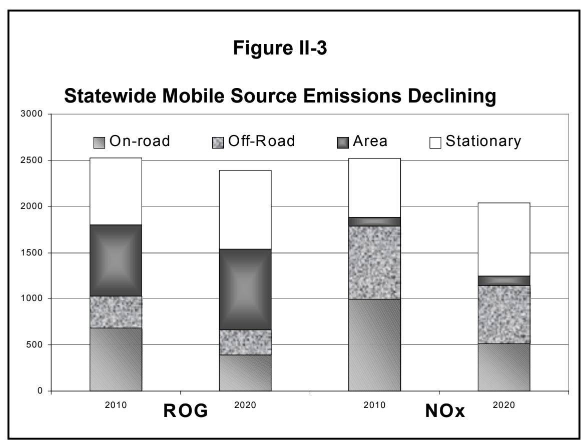
In the last decade, California has dramatically tightened standards for heavy-duty vehicles and off-road equipment as well. Some mobile sources are pre-empted from State authority to control, and some – due to interstate or international commerce issues – are not practical to control at the State level. These mobile sources are referred to as “federal sources.” California must rely on the federal government to control them. Federal sources include: interstate trucks registered outside California, farm and construction equipment (like bulldozers and tractors), trains, ships, and planes. ARB staff has worked closely and successfully with the United States Environmental Protection Agency (U.S. EPA) staff to develop, adopt, and implement harmonized regulations for interstate diesel trucks, off-road diesel equipment, and off-road equipment. The new federal emission standards requiring low-sulfur diesel fuel in 2006 and cleaner trucks in 2007 are critical to help reduce harmful exposure to ozone and particles in California.

Mobile source regulations have reduced motor vehicle exhaust emissions by approximately 99 percent over uncontrolled levels for all on-road sources in California. More than any other pollution control effort, ARB’s mobile source control program has moved the State’s nonattainment areas closer to meeting federal and State air quality standards.

Figure II-2 shows mobile source emissions, in tons per day, by category in 2000, 2010 and 2020. These categories include: heavy-duty vehicles; light-duty vehicles; gasoline equipment; diesel equipment; and ships, planes, and trains. Figure II-2 also clearly illustrates the benefits of ARB's mobile source and fuels programs. It shows reductions in ozone precursor emissions (i.e., ROG plus NOx emissions) from nearly every mobile source category as a result of ARB's existing control program (i.e., not including the measures in this draft SIP). As the California regulated fleet of mobile sources gets cleaner, the relative share of emissions from federally regulated sources such as ships, planes, and trains, increases. Nevertheless, with the ongoing joint efforts of ARB, U.S. EPA, and the local districts, mobile source emissions of ROG and NOx will continue to drop.



Mobile sources, both on- and off-road, are currently responsible for more than 70 percent of California's ROG and NOx emissions. The total statewide summer emissions in 2010 from all sources, under the existing control program, are estimated to be approximately 2,500 tpd each of ROG and NOx. By 2010, mobile sources will account for about 55 percent of the ozone precursor emissions, and by 2020, mobile source emissions are expected to account for less than 40 percent of ozone precursor emissions. See Figure II-3.



New engines are ever cleaner, but the number of vehicles and miles traveled are outpacing population growth. Plus, the lifetime of heavy-duty diesel trucks and equipment can extend over several decades, slowing air quality benefits that depend on fleet turnover.

Because on-road and off-road mobile sources together account for so much of the State's inventory of smog-forming emissions, further reductions in mobile source emissions are essential if clean air standards are to be realized. The mobile source element of the State Implementation Plan (SIP) is ARB's blueprint of technology- and market-based emission control strategies for achieving this outcome.

3. Proposed Strategies

Technological breakthroughs over the past 30 years made significant emission reductions possible. Over the next decade, ARB expects to see even greater advances through the development, commercialization, and use of zero and near-zero emission technologies, as well as further development of clean and alternative fuels. These emerging technologies hold promise for several reasons: tailpipe, evaporative and fuel marketing emissions will be eliminated, emission control equipment deterioration or failure will be a thing of the past, toxic and greenhouse gas emissions will be substantially reduced, and emissions associated with the traditional fuels infrastructure will be significantly reduced.

ARB's strategy for achieving additional emissions reductions from the mobile source emissions inventory can be grouped into five approaches: (a) set technology-forcing new engine standards; (b) reduce emissions from the in-use fleet; (c) require clean fuels, support alternative fuels, and reduce petroleum dependency; (d) work with U.S. EPA to reduce emissions from federal and State sources; and (e) pursue long-term advanced technologies measures. These five strategies would be implemented via the mobile source and fuels measures cited in this Section.

a. Set Technology-Forcing New Engine Standards

Technology-forcing emission standards for new vehicles and engines have been at the heart of ARB's mobile source control program. Progressively more stringent emission standards have helped spur improvements in combustion efficiency and advanced engine and aftertreatment technology. For many mobile source categories, more stringent standards were adopted under the existing program, and will be phased-in between now and 2010. Because the emission benefits of new emission standards are achieved as older engines are retired and new engines are purchased, the 2010 emission benefits of new emission standards adopted in the next several years are relatively slight. However, to achieve and maintain healthful air quality for California residents in the face of increased population, increased vehicle miles traveled, and increased equipment usage, the push toward zero emission technology is absolutely essential. Thus, ARB is proposing the next round of emission standards, which will be adopted during this decade and realize substantial emission benefits by 2020.

ARB staff is planning to propose new standards for large spark-ignited engines, such as forklifts, and for small off-road equipment (lawnmowers, leaf blowers, etc.). In addition, included in concepts the federal government should consider are new emission standards for locomotives, ocean-going ships, harbor craft, and commercial and non-tactical military aircraft.

b. Reduce Emissions from the In-Use Fleet

Incentive-based programs using public funds have been successful in reducing emissions of ROG and NOx. Some incentive programs, for example ARB's Lower-Emission School Bus Program and the Carl Moyer Program, are also achieving particulate matter (PM) reductions. However, the implementation of incentive-based programs was never intended to relieve the private sector of its ultimate responsibility to reduce emissions from the existing vehicle fleet. Therefore, ARB must now consider other options that require the aging vehicle and equipment fleet within California to reduce emissions and the associated impacts on our State's air quality over the next ten years.

Light- and Medium-Duty Vehicles: Inspection and Maintenance (or Smog Check) programs help ensure that in-use vehicles stay clean as they age. ARB and the Bureau of Automotive Repair (BAR) have implemented a number of near-term improvements to the Smog Check program. Three improvements that remain to be implemented include: 1) loaded-mode testing for gasoline trucks between 8,500 and 10,000 pounds gross vehicle weight, 2) an evaporative emission control test to identify excess ROG emissions from leaks in the fuel system, and 3) increasing the percent of vehicles sent to Test-Only stations.

In addition, ARB is currently conducting a Pilot Program to test both light- and medium-duty vehicles to determine the most effective means of reducing in-use emissions. Vehicle testing under the Pilot Program, which targets model year 1995 and older vehicles, will be completed by the end of 2003. The results of the pilot program will be used to determine the emission benefits and estimated costs of implementing light- and medium-duty vehicle part replacement/repair programs.

Heavy-Duty Vehicles and Equipment: ARB must also focus its efforts on reducing emissions from in-use on- and off-road heavy-duty diesel vehicle and equipment fleets. While stringent new emission standards will result in significant reductions – this will only occur over time. The durability and performance reliability of the heavy-duty diesel engine means that each one remains in service for an extended period of time, typically 500,000 miles to a million or more miles, diluting the near-term emissions impact of standards targeting only new engines. For both on-road and off-road diesel engines, ARB will be considering several strategies to reduce in-use emissions. Some examples of these strategies are fleet rules to reduce PM emissions, idling restrictions, and vapor recovery for cargo tanker fueling hoses. ARB also intends to implement a software upgrade program that specifically targets 1993 through 1998 model year on-road heavy-duty diesel engines. These software upgrades, developed by the engine manufacturers and available now, will significantly reduce excess NOx emissions during typical on-highway driving conditions.

c. Require Clean Fuels, Support Alternative Fuels, and Reduce Petroleum Dependency

Cleaner conventional and alternative fuels will reduce emissions and enable the new technology envisioned in this draft SIP.

One fuels measure, already adopted by the Board, lowers the maximum sulfur content allowed in diesel fuel to 15 ppm by 2006, and significantly reduces diesel PM levels for on-road and off-road vehicles statewide. Low sulfur diesel fuel enables technologies such as catalyzed diesel particulate filters and NOx adsorbers that can significantly reduce emissions from on- and off-road engines. Additional measures would control the sulfur in lubricating oil and set additive standards for diesel fuel to control engine deposits.

While tighter fuel specifications can enable the next generation of vehicle and equipment technology, alternative fuels and alternative diesel fuels can reduce emissions in the near-term. There are several mobile source and fuels measures that provide for the use of alternative fuels or alternative diesel fuels to yield near-term emissions benefits.

One sure way to reduce emissions from fuels is to use less of it. ARB will pursue approaches to reduce petroleum dependency, including looking at advanced technologies, alternative fuels and alternative diesel fuels, lowering travel demand, and reducing upstream emissions.

d. Work with U.S. EPA to Reduce Emissions from Federal and State Sources

Adopted U.S. EPA regulations for interstate diesel trucks and off-road equipment and the federal requirement for low-sulfur diesel fuel in 2006 for on-road trucks are critical parts of the strategy to attain federal ambient air quality standards. But significant additional reductions are needed, and the federal government needs to do more to control federal sources.

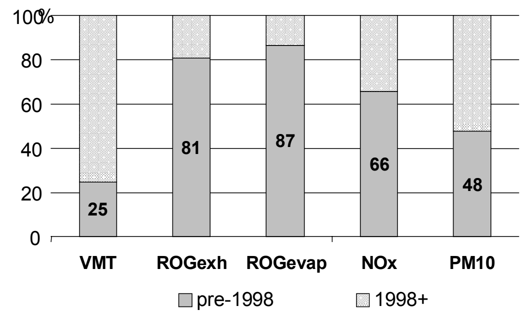
Suggested federal measures include: more stringent standards for off-road compression ignition engines; a federal requirement for low-sulfur diesel fuel for off-road engines, marine, and locomotive engines beginning in 2006; more stringent standards for harborcraft and ocean-going ships; and more stringent standards for aircraft engines, as well as reformulated jet fuel for aircraft engines.

e. Pursue Long-Term Advanced Technologies Measures

Light- and Medium-Duty Vehicles: There is a wide disparity in emissions between pre- and post-1998 light-duty vehicles. This variation is primarily due to the technological advancements in motor vehicle controls and vehicle design that occurred beginning in 1998, and the results of overall deterioration in the aging motor vehicle fleet. Figure II-4 illustrates how older engines in the light-duty fleet will contribute a disproportionate share of emissions relative to their population and usage in 2010.

Figure II-4

Older Gasoline Powered Vehicle Contribution Statewide Summer 2010



Other long-term advanced technology measures for light- and medium-duty vehicles include: 1) Voluntary Accelerated Vehicle Retirement (VAVR) – which requires funding, and 2) improvements to the Smog Check program – which would require legislative authority, including replacing the rolling 30-year model year exemption with the exemption of pre-1975 vehicles, and expanding Enhanced Smog Check.

Heavy-Duty Vehicles and Equipment: For both on- and off-road diesel engines, ongoing funding for incentive programs such as the Carl Moyer Program and the Lower-Emission School Bus Program would introduce cleaner technology and reduce in-use emissions. Other long-term advanced technology measures include lower U.S. EPA emission standards for new and remanufactured locomotive engines, additional marine reductions, including alternatives to dockside power and propulsion in/out of port and operational controls, and reduced emissions from vehicles traveling to and from airports.

Post-2010 Measures: In virtually every mobile source category, ARB has adopted more stringent emission standards that are being phased-in between now and 2010. There are a number of categories ARB plans to revisit, to adopt the next round of more stringent emission standards which will yield emission benefits after 2010. These post-2010 measures will help counter growth in population and activity, and continue to ensure healthy air in California. Post-2010 measures already planned include Tier IV emission standards for off-road diesel engines and for diesel recreational marine engines, low-emission vehicle (LEV III) standards for light-duty vehicles, exhaust and evaporative standards for off-road motorcycles, and more stringent standards for personal watercraft and outboard engines.

There is no doubt that ARB must move beyond traditional technologies, such as the internal combustion engine, to achieve our long-term clean air goals. Consequently, our future efforts will involve fundamental shifts to new technologies and fuels. One of our continuing goals is to encourage the development, commercialization, and use of zero and near-zero emission technologies in the post-2010 timeframe. ARB's Zero Emission Vehicle (ZEV) Program has been a major catalyst in the research and development of a variety of technologies for the mobile sector. Fuel cell technology is the most likely candidate to replace today's technology in the post-2010 timeframe. Other technologies, including hybrid-electrics and micro-turbines are being developed.

These advanced technologies, coupled with the fueling infrastructure to support them, will move California into a cleaner, healthier future.

CHAPTER A

Light and Medium-Duty Vehicles

CHAPTER A. LIGHT AND MEDIUM-DUTY VEHICLES

1. Category Description

Mobile sources are responsible for about 70 percent of the ozone-forming emissions in California. Light- and medium-duty vehicles, as a segment of mobile sources, consist of passenger cars, small and large trucks, vans, sport-utility vehicles, and mid-sized delivery vehicles. The relative contribution of light- and medium-duty vehicles is expected to decline over time as new standards phase in. Even so, in 2010 such vehicles will still be responsible for over half of total ROG emissions, approximately 30 percent of the NOx emissions and approximately 20 percent of the inhalable particulate matter (PM10) emissions from all mobile sources. About 40 percent of the ROG emissions from light- and medium-duty vehicles are attributable to evaporative emissions.

In addition to ROG, NOx and PM10, light- and medium-duty vehicles are a significant source of emissions of carbon monoxide (CO), toxic air contaminants in California, and a major contributor to greenhouse gas emissions. The facilities needed to refuel the current light- and medium-duty vehicle fleet (service stations, bulk terminals, refineries) present another source of smog precursors, air toxics, water pollution, and hazardous waste. Emissions of criteria pollutants from light- and medium-duty vehicles (up to 14,000 pounds gross vehicle weight) are shown in Tables II-A-1, II-A-2 and II-A-3 for the South Coast and the San Joaquin Valley. In addition, Table II-A-4 shows baseline emissions for on-road motorcycles in the South Coast.

Table II-A-1
Baseline Emissions for Light and Medium-Duty Vehicles up to 14,000 Pounds Gross Vehicle Weight
(South Coast, Summer Planning, tpd)

Pollutant	2000	2005	2006 (annual average)	2008	2010	2020
ROG	364	233	220	189	165	96
NOx	374	236	236	189	163	80
PM10	117	13	13	13	14	16
CO	3758	2352	2211	1885	1627	824

Note: Brake and tire wear are included in PM10 inventory.

Table II-A-2
Baseline Emissions for Passenger Cars and Light-Duty Trucks
(San Joaquin Valley, Winter Planning, tpd)

Pollutant	2010
ROG	43
NOx	44
PM10	3.5

Note: Brake and tire wear are included in PM10 inventory.

Table II-A-3
Baseline Emissions for Gasoline Vehicles up to
14,000 Pounds Gross Vehicle Weight
(San Joaquin Valley, Winter Planning, tpd)

Pollutant	2010
ROG	50
NOx	54
PM10	3.9

Note: Brake and tire wear are included in PM10 inventory.

Table II-A-4
Baseline Emissions for Motorcycles
(South Coast, Summer Planning, tpd)

Pollutant	2010
ROG	5.2
NOx	1.4
PM10	0.1

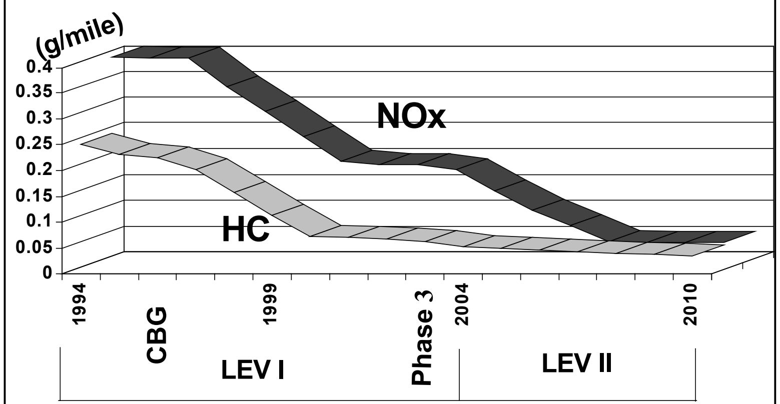
Note: Brake and tire wear are included in PM10 inventory.

2. Existing Control Program

The Low-Emission Vehicle (LEV) regulations are the cornerstone of ARB's efforts to reduce emissions from light- and medium-duty vehicles. The original LEV I program was adopted in 1990. ARB adopted the second phase of its Low-Emission Vehicle program (LEV II) in November 1998. Both the LEV I and LEV II regulations include four primary elements: (1) increasingly stringent exhaust emission standards for specific categories of low-emission vehicles, (2) an increasingly stringent annual fleet average standard for non-methane organic gas (NMOG) which requires each manufacturer to phase-in a progressively cleaner mix of vehicles from year to year, (3) banking and trading provisions, and (4) a requirement that a specified percentage of passenger cars and lighter light-duty trucks be zero emission vehicles (ZEVs), vehicles with no emissions. Figure II-A-1 illustrates the emission standards set forth by the LEV program by model year.

Figure A-1

Emission Standards for LEV Program



a. Low-Emission Vehicle Program (LEV I)

The LEV I program established four low-emission vehicle categories to which a car or light-duty truck could be certified: Transitional Low-Emission Vehicle (TLEV), Low-Emission Vehicle (LEV), Ultra Low-Emission Vehicle (ULEV), and Zero Emission Vehicles (ZEV). The medium-duty vehicle categories are LEV, ULEV, Super Ultra Low-Emission Vehicle (SULEV), and ZEV. Each low-emission vehicle category has a progressively more stringent standard for exhaust emissions of NMOG. For example, passenger car LEVs and ULEVs have to meet standards for NMOG that are respectively about one-third and one-sixth of the corresponding federal 1994 Tier 1 non-methane hydrocarbon (NMHC) standard. The identical LEV and ULEV standard for oxides of nitrogen (NOx) represents a 50 percent reduction from the federal 1994 Tier 1 NOx standard.

All passenger cars have been subject to the same low-emission vehicle standards, regardless of weight. However, heavier light-duty trucks and medium-duty vehicles were allowed to have greater emissions for given low-emission vehicle categories. There were two weight categories for light-duty trucks (LDT1 and LDT2) and four weight categories for medium-duty vehicles (MDV2, MDV3, MDV4, and MDV5).

Under LEV I, each year a manufacturer may produce cars and LDT1s certified to any combination of emission categories – TLEV, LEV, etc. – as long as its full model line meets the annual NMOG fleet average requirement. The required fleet average NMOG emissions level starts at the Tier 1 level for the 1994 model year. It then becomes incrementally more stringent through the 2003 model year, when the level for cars and LDT1s was derived from a potential mix of 75 percent LEVs, 15 percent ULEVs and 10 percent ZEVs. The heavier light-duty trucks in the LDT2 category are subject to numerically higher fleet average NMOG emissions requirements reflecting the numerically higher TLEV, LEV and ULEV standards and the absence of a ZEV requirement for these vehicles. Medium-duty vehicles have separate requirements based on a percent phase-in schedule.

An integral part of LEV I is the requirement for specific percentages of ZEVs. This requirement, often referred to as the "ZEV program," is an essential part of California's mobile source control efforts and is intended to encourage the development of advanced technologies that will secure increasing air quality benefits for California now and into the future. A more detailed discussion of the ZEV program is included below.

b. Low-Emission Vehicle Program II (LEV II)

While the LEV I program established the ZEV program and set forth increasingly stringent vehicle tailpipe emission standards from 1994 through 2003, LEV II continued that trend by setting even more stringent emission requirements beginning in 2004 and continuing through 2010. The LEV II program was adopted in 1998 with the intent of satisfying the requirements of the Improved Control Technologies (M2) measure of the 1994 State Implementation Plan (SIP) obligations and a significant portion of the SIP's so-called "black box." LEV II meets its SIP goals by reducing ozone precursors in the South Coast Air Basin by 57 tons per day by 2010.

One of the principal goals of the LEV II program is to ensure that the increasingly popular sport utility vehicles (SUV) and pickup trucks that are being used primarily as passenger cars be required to meet the same emission requirements as passenger cars. Thus, all light-duty trucks and all medium-duty vehicles having a gross vehicle weight (GVW) of less than 8,500 pounds will be subject to the LEV II passenger car exhaust emission standards. Only vehicles having a GVW of 8,500-14,000 pounds – the MDV4 and MDV5 categories – will remain as medium-duty vehicles. Another goal of the program is to dramatically reduce NOx emissions for all vehicles below 8,500 pounds to a level 75 percent below that allowed for passenger cars in the LEV I program. The LEV II standards for the various vehicle emissions categories are phased in during the 2004-2007 model years.

In 1995, the U.S. Environmental Protection Agency (U.S. EPA), ARB and the automobile manufacturers signed a Statement of Principles that states:

> "... the Signatories commit to working together to achieve regulatory streamlining of light-duty vehicle compliance programs, including reduction of process time and test complexity, with the goal of more optimal resources spent by both government and industry to better focus on in-use compliance with emission standards."

ARB staff worked with U.S. EPA and the automobile industry to develop a streamlined motor vehicle certification process coupled with an enhanced in-use compliance program, the Compliance Assurance Program. The goal of U.S. EPA and ARB in this compliance program is to redirect manufacturer and government efforts toward in-use compliance, which would provide greater assurance that vehicles are actually complying with the standards while in-use. The LEV II regulations divert the significant resources presently devoted to motor vehicle certification and reallocate a portion of them towards in-use compliance. Reducing the regulatory burden during certification would provide manufacturers with more control over their production timing, which would provide significant savings, while the enhanced in-use test programs would provide more air quality protection. This proposal became effective with the 2001 model year although manufacturers could certify their 2000 model year vehicles using the compliance program framework as adopted by the Board.

Subsequent to adoption of the LEV II program, ARB staff assisted the U.S. EPA in developing a similar program for federal vehicles that would achieve maximum emission reductions for vehicles in other states. ARB staff met with U.S. EPA staff to review the engineering approach taken in ARB's test program, provide them with emission test data, loan them experimental catalysts, and provide other assistance. U.S. EPA staff demonstrated that emission levels adopted in LEV II could also be achieved cost-effectively on vehicles nationwide. The program that was subsequently adopted by U.S. EPA in January 1999 is referred to as the Tier 2 standards.

While Tier 2 was patterned after the LEV II program, there was a significant difference in that California has a NMOG fleet average requirements, whereas Tier 2 vehicles must meet a NOx fleet average requirements. This difference could have potentially resulted in manufacturers certifying certain vehicles models to a more stringent federal standard than is required in California. This would most likely have occured when vehicles previously classified as medium-duty vehicles are transitioning to the light-duty truck classification during the 2004 through 2006 model years. Thus, to ensure that only the cleanest vehicles are available in California, the Board approved modifications to the LEV II regulations in December 2000 that require a manufacturer to certify California vehicle models to the most stringent emission standards categories available whether that be the Tier 2 or California standards.

c. Zero Emission Vehicle Program

As discussed above, under the LEV I regulations, the seven largest auto manufacturers were required to produce ZEVs beginning with model year 1998. In model years 1998 through 2000, two percent of the vehicles offered for sale in California by large volume manufacturers were to be ZEVs, and this percentage was to increase to five percent in model years 2001 and 2002, and ten percent in model years 2003 and beyond.

In 1996, ARB modified the regulations to allow additional time for the technology to develop. The requirement for ten percent ZEVs in model years 2003 and beyond was maintained, but the sales requirement for model years 1998 through 2002 was eliminated. At that same time, ARB entered into Memoranda of Agreement (MOAs) with the seven largest vehicle manufacturers. Under the MOAs, the manufacturers agreed to place more than 1,800 advanced-battery electric vehicles in California in 1998 through 2000, and ARB agreed to work with State and local governments to help develop ZEV infrastructure and remove barriers to ZEV introduction.

In 1998, ARB adopted changes to the ZEV program that allowed extremely clean conventional vehicles to meet a portion of the pure ZEV requirements. Under the changes, manufacturers were able to certify to a new standard, the partial credit zero emission vehicle (PZEV). Intermediate-sized automakers could meet their entire ZEV obligation with PZEVs, whereas large manufacturers were still required to meet, at a minimum, four percent of their sales with vehicles classified as "pure" ZEVs.

In January 2001, the ZEV program was modified to reflect the state of battery technology and to respond to new advances in vehicle technology. These modifications included:

- Allowing manufacturers to generate "credit" toward their ZEV requirement with vehicles that have advanced componentry.
- Increasing ZEV credit for hybrid vehicles with specific amounts of all-electric range.
- Allowing additional ZEV credit for ZEVs placed in transportation systems such as station car programs.
- Phasing in a ZEV requirement for larger trucks and sport utility vehicles.
- Some technical modifications to the ZEV credit calculation mechanism.

In April 2003, ARB adopted changes to the program to address issues raised in ongoing litigation of the program in State and federal court, and to further refine the program to reflect the state of vehicle technology. In addition to removing all references to fuel economy and efficiency, the modified program established an alternative compliance path for automobile manufacturers.

Auto manufacturers can fulfill their ZEV obligations by meeting standards that are similar to the 2001 ZEV program. This means using a formula allowing a vehicle mix of two percent pure ZEVs, two percent AT PZEVs (vehicles earning "advanced technology" partial ZEV credits) and six percent PZEVs.

Conversely, a manufacturer may choose an alternative ZEV compliance strategy, meeting part of their ZEV requirement by producing their sales-weighted market share of 250 fuel cell vehicles by 2008. The remainder of their ZEV requirements can be achieved by producing four percent AT PZEVs and six percent PZEVs. The required total number of fuel cell vehicles will increase to 2,500 from 2009 to 2011, 25,000 from 2012 to 2014 and 50,000 from 2015 through 2017. Automakers can substitute battery electric vehicles for up to 50 percent of their fuel cell vehicle requirements.

The Board made further modifications to the regulation to encourage the continued research and development of battery electric vehicles including an increase in the credit awarded for vehicles in-use beyond three years and removal of the battery warranty requirement. The Board also increased the credit for grid-connected hybrid electric vehicles and allowed a manufacturer to receive credit for fuel cell vehicles placed in other states that have adopted California's ZEV program.

To report on ZEV technology progress, costs and consumer acceptance, ARB will establish an independent review panel of technology/industry experts. In addition, ARB staff will report annually on the progress of the ZEV program. As a result of the 2003 modifications brought on by the automaker lawsuits, the program requirements will not go into effect until 2005. However, automakers can receive credit for any ZEV, PZEV or AT PZEV vehicles they choose to sell until then.

There are two recently approved programs undertaken to strengthen the success of the ZEV program: the ZEV Incentive Program (ZIP) and the regulatory standardization of electric vehicle infrastructure.

The ZIP Program: The ZIP program was established by the passage of Assembly Bill (AB) 2061 (Lowenthal) in 2000. AB 2061 appropriated an $18,000,000 fund to grant incentives to the purchasers or lessors of zero emission vehicles between October 2000 and December 2002. The program grants up to $3,000 each year for three years (totaling $9,000) for the purchase or lease of a freeway capable zero emission vehicle. As a result of this program, as many as 2,000 electric vehicles could be subsidized. This program is important to the early success of the ZEV program as the cost of electric vehicles is currently quite high. By providing grants to consumers and fleets, the price of these ZEVs can be brought down to levels comparable to conventionally fueled vehicles.

In addition to the already established ZIP program, the 2001/2002 fiscal year budget included $20,000,000 towards incentives for ZEVs. This new infusion of incentive money provides up to $5,000 per ZEV for as many as 2,000 additional ZEVs and also creates incentives of up to $11,000 for fleet vehicles operated in disproportionately impacted low income and minority communities. This funding will cover vehicle placements through 2004.

Charger Standardization: The standardization of electric vehicle charging infrastructure is essential to the success of the ZEV program. In June 2001, the Air Resources Board approved a regulatory addition to the ZEV regulations, which establishes the requirement that all vehicles that earn ZEV credit must be compliant with a standard charging technology. One of the barriers identified to commercial success of electric vehicles was the lack of a single charging standard. The market was faced with multiple charging technologies. This regulatory action ensures that all electric vehicles will be able to make use of all public charging facilities and will reduce cost and confusion in the electric vehicle market.

Standardization may result in increased public acceptance of electric vehicles because of clarification over charging technology, which may result in increased sales. Additionally, a single charging technology may result in increased penetration of public charging sites because of reduced costs. This could increase the effective range and usefulness of electric vehicles which results in increased zero emission miles traveled.

d. Smog Check Program

Inspection and maintenance (or Smog Check) programs are meant to help ensure that in-use vehicles stay clean as they age. The Smog Check programs are important strategies to improve air quality and protect public health by reducing vehicle emissions. California has three types of Smog Check programs, all administered by the Bureau of Automotive Repair (BAR):

- Enhanced Smog Check in the State's smoggiest urbanized regions;
- Basic Smog Check in the remaining urbanized areas of the State; and
- Change-of-ownership Smog Check in most rural parts of the State.

Basic and change-of-ownership Smog Check use an idle test to measure hydrocarbon (HC) and carbon monoxide (CO) emissions from vehicles. The distinguishing features of Enhanced Smog Check include:

- Loaded-mode testing, i.e., testing on a treadmill-like device that allows measurement of NOx emissions, in addition to HC and CO; and
- Inspection of vehicles most likely to have high emissions at test-only stations, i.e., stations that perform only tests and are prohibited from performing repairs.

In the 1994 California State Implementation Plan (1994 SIP), California committed to achieve emission reductions with Enhanced Smog Check. After a comprehensive evaluation in 2000, ARB determined that although Enhanced Smog Check was reducing emissions, it was not achieving the full emission reductions required by the 1994 SIP. Therefore, in August 2000, ARB and BAR jointly committed to U.S. EPA to implement the following near-term improvements to Enhanced Smog Check to address the emission reduction shortfall:

- More stringent inspection standards for oxides of nitrogen;
- Loaded-mode testing for heavy-duty gas trucks;
- Improved evaporative emission testing, including a test for liquid fuel leaks;
- Directing more vehicles to Test-Only stations; and

- Use of remote sensing.

No emission reductions were claimed for remote sensing.

In addition to the near-term improvements, ARB and BAR committed to work together to pursue additional mid-term program improvements to provide the remainder of the needed reductions. Potential legislative options identified included:

- Removing the rolling 30-year model year exemption, i.e., the exemption that will exclude all vehicles older than 30 years from the Smog Check program; and
- Extending Enhanced Smog Check beyond the current definition of urbanized area to include all eligible vehicles registered in a nonattainment region subject to Smog Check.

A significant number of the near-term improvements have been implemented. Since August 2000, BAR has tightened inspection standards for both NOx and HC and has directed more vehicles to test-only stations. The HC inspection standards were tightened beyond what was anticipated in the Enhanced Smog Check improvement commitments. BAR also added a test for liquid fuel leaks to Smog Check inspections in September 2001. Finally, the Enhanced Smog Check program area has been expanded. Many districts including San Joaquin Valley, Sacramento, Yolo-Solano, South Coast, and Ventura County have voluntarily chosen to work with BAR to begin to expand the Enhanced Smog Check program within their districts. ARB and BAR are working together to implement the remaining near-term and mid-term improvements, as well as to expand the most rigorous form of Smog Check, Enhanced Smog Check, to as many areas of the State as possible.

e. Motorcycle Control Program

Emission standards for on-road motorcycles were first adopted in 1975 and implemented in 1978. These standards regulated hydrocarbons and carbon monoxide for all motorcycle engines 50 cubic centimeters (cc) and greater. The ARB amended these regulations in 1984, allowing emission standards to be met on a “corporate average” basis while tightening the HC and CO standards. In 1998, ARB adopted a new set of standards that will apply to 280 cc and larger motorcycles beginning in the 2004 model year. Further reductions will be required in the 2008 model year. Current California law prohibits any modifications which would increase emissions in post-1978 motorcycles.

3. Proposed Strategies

Two additional emission reduction measures are proposed for light and medium-duty vehicles. The implementation schedule for these measures is listed in Table II-A-5.

Table II-A-5
Proposed Strategy for Light and Medium-Duty Vehicles

Strategies	Timeframe	
	Action	Implementation
LT/MED-DUTY-1: Replace or Upgrade Emission Control Systems on Existing Passenger Vehicles – Pilot Program	2005	2007 - 2008
LT/MED-DUTY-2: Improve Smog Check to Reduce Emissions from Existing Passenger and Cargo Vehicles	2002 - 2005	2002 - 2006

a. LT/MED-DUTY-1: Replace or Upgrade Emission Control Systems on Existing Passenger Vehicles – Pilot Program

Time Frame: Adopt 2005; Implement 2007-2008

Responsible Agency: ARB

Proposed Strategy:

ARB is currently performing a test program to evaluate the potential benefits of mandatory replacement of catalysts, oxygen sensors and evaporative emission carbon canisters on older passenger cars. These components are the heart of a modern emission control system and deteriorate during the life of a vehicle through thermal stress, and chemical contamination. While it is known that these components deteriorate the benefits associated with their replacement are less certain because of interactions between the "new" parts and the other "old" parts of a vehicle. It is also possible that such a program could specify lower cost "new" parts, because the remainder of the vehicle's life is expected to be much shorter than its age at the time of retrofit. The performance of the low cost parts needs to be evaluated compared to the old parts on the cars and to new factory (higher cost) parts.

The data being produced by this program needs to include enough cars to provide reasonable confidence in its conclusions; testing one car takes a couple of weeks. So the decision on whether to proceed with a mandatory program is expected to occur in 2004, with regulations to follow in 2005, if the pilot program shows the potential for significant benefits at reasonable cost and funding can be identified. The program would be implemented in 2007 or 2008, with benefits between zero (decision not to proceed) to 19 tpd of ROG and 18 tpd of NOx in the South Coast Air Basin in 2010. The benefits for the South Coast and the San Joaquin Valley are summarized in Tables II-A-6 and II-A-7.

Table II-A-6
LT/MED-DUTY-1: Replace or Upgrade Emission Control Systems on Existing Passenger Vehicles – Pilot Program
(South Coast, Summer Planning, tpd)

Pollutant	2010
ROG	0-19
NOx	0-18
CO	0-140

Table II-A-7
LT/MED-DUTY-1: Replace or Upgrade Emission Control Systems on Existing Passenger Vehicles – Pilot Program
(San Joaquin Valley, Winter Planning, tpd)

Pollutant	2010
ROG	0-2.4
NOx	0-2.7
PM10	0

<u>SIP Commitment for Measure LT/MED-DUTY-1</u>

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board by 2005. The measure as proposed to the Board will, at a minimum, achieve between 0 and 19 tpd of ROG reductions and between 0 and 18 tpd of NOx reductions in the South Coast Air Basin in 2010.

San Joaquin Valley 2003 PM10 SIP Commitment:

On June 26, 2003, the Board approved State commitments for the San Joaquin Valley's PM10 SIP. ARB staff commits to complete the Pilot Program and propose a control measure if the approach described above proves to be feasible and effective. If the approach is found to be feasible and effective, the Board will consider this measure by 2005. Emission reductions from this measure will be used toward meeting ARB's commitment to adopt new measures between 2002 and 2008 that reduce emissions by an additional 10 tpd NOx and 0.5 tpd direct PM10 in the San Joaquin Valley by 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

b. LT/MED-DUTY-2: Improve Smog Check to Reduce Emissions from Existing Passenger and Cargo Vehicles

Time Frame: Action 2002-2005; Implement 2002-2006

Responsible Agency: Bureau of Automotive Repair and ARB

Proposed Strategy:

The following three improvements to Enhanced Smog Check, which ARB and BAR committed to in August 2000, will provide additional emission reductions – the first has been implemented, the second was adopted but has not yet been implemented, and the third is still in development:

(1) Test-Only Direction Increase: As of a year ago, about 20 percent of vehicles subject to Enhanced Smog Check were being inspected at Test-Only stations. BAR studies have shown that greater emission reductions are achieved when vehicles are directed to Test-Only stations rather than Test and Repair stations. BAR steadily increased the percent of vehicles sent to Test-Only stations and reached 36 percent by December 2002.

(2) Gasoline Trucks Loaded-Mode Testing: Currently, gas trucks between 8,500 and 10,000 pounds gross vehicle weight rating (GVWR) in the Enhanced Smog Check program are subject to the two-speed idle test, but excluded from the loaded-mode test. ARB and BAR have developed loaded-mode test protocols and inspection standards for these vehicles. BAR adopted the regulations and the Office of Administrative Law has now approved them as well. BAR plans to implement the program as soon as possible. The requirement for loaded-mode testing will apply to heavy-duty gas trucks between 8,500 and 9,999 GVWR in the Enhanced Smog Check inspection program areas.

(3) Evaporative Emission Control Test: With tailpipe emissions becoming a smaller portion of the mobile source inventory, maintaining in-use evaporative emission controls becomes more important. Evaporative emission reductions could be achieved by requiring a low-pressure evaporative test. The low-pressure evaporative test would identify excess ROG emissions from leaks in the fuel system and help facilitate necessary repairs. BAR has developed a low-pressure evaporative test prototype and is working to develop a reasonably priced low-pressure test device. BAR is working on developing regulations for a low-pressure evaporative test and implementing it as soon as possible.

Since BAR has the regulatory authority in California for the Smog Check program, we have included evidence of BAR's commitment to implement these improvements as Appendix I-1 in Section I of this document. Upon SIP approval by ARB and U.S. EPA, the combination of the improvements described in this measure and BAR's existing Enhanced Smog Check program would revise and entirely replace the prior State commitments (originally established in the 1994 SIP) for California's Enhanced Vehicle Inspection and Maintenance Program.

Emission benefits associated with the Smog Check improvements are shown in Tables II-A-8 and II-A-9 for the South Coast and the San Joaquin Valley, respectively.

Table II-A-8
LT/MED-DUTY-2: Improve Smog Check to Reduce Emissions from Existing Passenger and Cargo Vehicles
Estimated Emission Reductions
(South Coast, Summer Planning, tpd)

Pollutant	2010
ROG	5.6-5.8
NOx	8.0-8.4
CO	58

Table II-A-9
LT/MED-DUTY-2: Improve Smog Check to Reduce Emissions from Existing Passenger and Cargo Vehicles
Estimated Emission Reductions
(San Joaquin Valley, Winter Planning, tpd)

Pollutant	2010
ROG	1.5
NOx	3
PM10	0

SIP Commitment for Measure LT/MED-DUTY-2

South Coast 2003 SIP Commitment:

ARB expects that BAR will act on these Smog Check improvements between 2002 and 2005 to achieve between 5.6 and 5.8 tpd of ROG reductions and between 8.0 and 8.4 tpd of NOx reductions in the South Coast Air Basin in 2010.

San Joaquin Valley 2003 PM10 SIP Commitment:

On June 26, 2003, the Board approved State commitments for the San Joaquin Valley's PM10 SIP. ARB expects that BAR will act on these Smog Check improvements between 2002 and 2005. Emission reductions from this measure will be used toward meeting ARB's commitment to adopt new measures between 2002 and 2008 that reduce emissions by an additional 10 tpd NOx and 0.5 tpd direct PM10 in the San Joaquin Valley by 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

4. Long-Term Advanced Technologies Measures

Additional emission reductions from light and medium-duty vehicles could be achieved through development and implementation of technological advances, availability of financial incentives, or legislative action. A number of these approaches are presented in this section.

Provide Incentives for Voluntary Passenger Vehicle Retirement: Currently, there are several types of vehicle retirement programs operating throughout California. One of these programs is run by the Bureau of Automotive Repair (BAR) and accepts only vehicles that fail the Smog Check inspection. The emission benefits of BAR's program are used to meet air quality goals; no tradeable emission credits are generated. Other retirement programs are operated by private enterprises under local air district control and only accept vehicles that pass the Smog Check inspection. Emission benefits from the programs funded with air district incentive funds are used to meet air quality goals. Emission benefits from other programs can generate emission reduction credits that can be used by air districts or by industry to offset excess emissions.

An additional vehicle retirement proposal would accept vehicles that have passed their most recent Smog Check inspection. By accepting only vehicles that pass their Smog Check inspection into the program, the measure would avoid double-counting emission benefits from the BAR retirement and repair programs. The measure would not allow for credit trading; all emission benefits would be counted toward air quality attainment goals. The emission benefits and cost-effectiveness of a vehicle retirement program would be entirely dependent on the amount of funding available.

Set Tighter Emission Standards for New Passenger Vehicles [Low Emission Vehicle III]: In 1998, ARB adopted the second generation Low-Emission Vehicle Program (LEV II) which significantly lowered emissions for light- and medium-duty vehicles. The program allows significant compliance flexibility in implementing the standards by use of an increasingly more stringent fleet average requirement. Vehicles in the lower weight classes of the light- and medium-duty categories have lower fleet average requirements because the zero emission vehicle requirement lowers the fleet average for those vehicles. Manufacturers can use credits from one fleet average to offset any debits that may occur in the other fleet average.

LEV III would incorporate two changes to the emission standards in the LEV II program: 1) lowering the fleet average emission standards for all weight classes; and 2) lowering the LEV II, LEV and ULEV exhaust emission standards.

In addition to these two changes to the emission standards, a third generation on-board diagnostic (OBD) system, OBD III could be implemented. Under OBD III, all

OBD II-equipped light- and medium-duty vehicles would be capable of electronically communicating with an off-board computer when a malfunction is detected by the OBD system. When a malfunction is identified, the owner would be notified of the malfunction and would be required to repair the vehicle within a specified time interval. Additional emission benefits could be achieved by utilizing the diagnostic capability of OBD II systems to provide timely repair of malfunctioning emission control components, thereby improving the effectiveness of the current Smog Check program. This enhanced on-board diagnostics system could also improve consumer convenience, further increasing the effectiveness of the current programs.

The anticipated emission benefits associated with this proposal would be realized in the post-2010 timeframe.

Additional Improvements to Smog Check: A number of additional improvements to the current Smog Check program could be achieved through legislative action:

Allow Districts to Opt in to Test-Only Program: Currently, for attainment areas, unclassified areas, moderate nonattainment areas, and non-urbanized serious, severe, and extreme nonattainment areas, State law allows air districts to request BAR to implement the Enhanced Smog Check program, excluding the test-only requirement. Recently, several air districts chose to implement the Enhanced Smog Check program in their areas. However, current law prohibits air districts from opting into the test-only portion of the Enhanced Smog Check program. If legislation authorizing air districts to also opt in to the test-only portion of the Enhanced Smog Check program were passed, this Smog Check improvement option could provide the air districts about 30 percent more in benefits than the Enhanced Smog Check program without the test-only element.

Replace Rolling 30-year Exemption with Exemption of pre-1975 Vehicles: Originally, the Smog Check inspection program applied to all 1966 and newer gasoline vehicles. In 1997, the State Legislature modified the Smog Check program to exempt pre-1975 vehicles, and beginning in January 2003, to exempt motor vehicles 30 or more model-years old. Because older vehicles contribute a disproportionate amount of emissions (despite their relatively low numbers and use), excluding these older vehicles from the program reduced the effectiveness of the Smog Check program. Replacing the 30-year rolling exemption with exemption of pre-1975 vehicles would achieve additional emission reductions in future years. In addition, these vehicles would also be eligible for other BAR assistance programs such as vehicle retirement and repair assistance.

Expand Enhanced Smog Check: Currently, California has two types of smog check inspection tests, two-speed idle and loaded-mode. The two-speed idle test measures HC and CO under idle conditions. The loaded-mode test uses a treadmill-like device to measure NOx in addition to HC and CO. The loaded-mode test closely simulates real world driving conditions and is more adept at identifying failures in new vehicles. If loaded-mode testing were fully implemented, additional emission reductions could be achieved.

CHAPTER B

On-Road Heavy-Duty Engines and Vehicles

CHAPTER B. ON-ROAD HEAVY-DUTY ENGINES AND VEHICLES

1. Category Description

Under ARB's current program to control emissions from mobile sources, heavy-duty vehicles, regardless of fuel type, are defined as vehicles with gross vehicle weight ratings (GVWRs) greater than 14,000 pounds. The heavy-duty vehicle category, which is dominated by diesel-fueled vehicles, includes vehicles such as dump trucks, solid waste collection vehicles, fuel cargo tankers, larger delivery trucks, urban buses and school buses, motor homes, and line haul trucks.

Heavy-duty diesel vehicles are major contributors to California's continuing air quality challenges. Per vehicle, they emit relatively high levels of NOx and particulate matter (PM). Based on emission modeling estimates for the South Coast Air Basin (SCAB), heavy-duty diesel vehicles will emit about 50 percent of the NOx emissions and about 37 percent of the exhaust PM emissions from all on-road mobile sources in 2010. These are significant contributions – particularly since these vehicles represent about two percent of the total on-road fleet. While stringent standards have already been adopted by ARB and U.S. EPA to curb these emissions, growth in the vehicle population and in vehicle miles traveled (VMT) have largely offset the per-vehicle reductions resulting from existing regulations.

In contrast to their high NOx and PM emissions, heavy-duty diesel vehicles have relatively low emissions of carbon monoxide (CO), carbon dioxide (CO2), and reactive organic gases (ROG). Nonetheless, these emission impacts are important due to the potential of CO to create "hot spots" that affect public health (although nearly all areas of California are in CO attainment), the role of CO2 in global warming, and the reaction of ROG in the atmosphere to form ozone and PM.

The baseline emission inventories for the South Coast Air Basin and the San Joaquin Valley for all on-road heavy-duty diesel vehicles with GVWRs greater than 14,000 pounds are shown in Tables II-B-1 and II-B-2 below. These estimates, based on ARB's emission inventory modeling program, EMFAC2002 version 2.2, represent the emissions contribution of heavy-duty diesel vehicles before implementation of any of the proposed measures discussed in this chapter.

Table II-B-1
Baseline Emissions for
On-Road Heavy-Duty Diesel Vehicles >14,000 lbs GVWR
(South Coast, Summer Planning, tpd)

Pollutant	2000	2005	2006 (Annual Average)	2008	2010	2020
ROG	10	10	10	9	9	6
NOx	299	287	290	255	221	96
PM10 (exhaust)	6	5	5	5	4	3
CO	50	48	47	45	42	35

Table II-B-2
Baseline Emissions for
On-Road Heavy-Duty Diesel Vehicles >14,000 pounds GVWR
(San Joaquin Valley, Winter Planning, tpd)

Pollutant	2010
ROG	4.4
NOx	85
PM10 (exhaust)	2.2

The baseline emissions in Tables II-B-1 and II-B-2 also include the emissions impact in California from heavy-duty diesel trucks that are registered in other states. Emission estimates from EMFAC2002 incorporate the assumption that about 25 percent of the VMT in California, and thus the associated emissions, are from vehicles in the heavy heavy-duty diesel vehicle category (diesel vehicles with GVWRs greater than 33,000 pounds) that are registered out of state, but that travel a portion of time within California.

Heavy-duty gasoline vehicles are relatively small contributors of the total mobile source emission inventory, emitting about two percent of the ROG plus NOx emissions. Table II-B-3 shows the emission inventory for heavy-duty gasoline vehicles in 2010 in the South Coast.

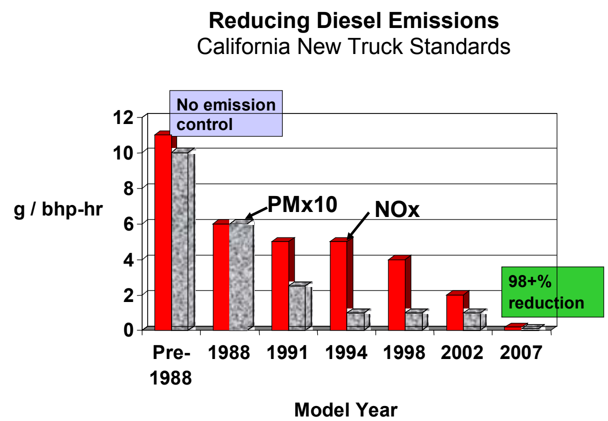
Table II-B-3
Baseline Emissions for
Heavy-Duty Gas Vehicles >14,000 lb GVWR
(South Coast, Summer Planning, tpd)

Pollutant	2010
ROG	13.6
NOx	20.0
PM10	0.1
CO	135.1

2. Existing Control Program

The federal Clean Air Act grants California the authority to adopt and enforce rules to control mobile source emissions within California – California is the only state in the nation with the authority to establish its own unique motor vehicle control program. In doing so, however, ARB is required to adopt State requirements that are as stringent, or more stringent, than the federal requirements.

Figure II-B-1



In 1969, when ARB first began regulating new heavy-duty vehicles, exhaust standards targeted only ROG and CO emissions. Since then, ARB has expanded its approach and has gradually reduced NOx and PM emissions by over 95 percent from the mid-1980s to the near-zero levels of the 2007 standards, as shown in Figure II-B-1. ARB staff has worked closely with U.S. EPA to develop a harmonized federal and California program to more effectively control emissions from new heavy-duty trucks. When it has been feasible to do so, the Board has adopted a more stringent program than the federal program. An example of such action is ARB's urban bus regulation adopted by the Board in February 2000. ARB's efforts have also focused on ensuring maximum emission reductions through the adoption of engine test procedures that more accurately measure emissions that occur during typical in-use driving conditions. These components, all described in this chapter, are the backbone of ARB's program and will support additional future measures to ensure new engines maintain low emissions, to ensure existing engines emit at the lowest feasible levels, and to push heavy-duty technology to achieve zero emissions, where possible.

a. 2004 and Later Model Year Emission Standards

Since 1998, heavy-duty diesel engines, exclusive of urban bus engines, have been required to certify to a 4.0 grams per brake horsepower-hour (g/bhp-hr) NOx standard and a 0.10 g/bhp-hr PM standard. Urban bus engines produced for sale in California have generally been subject to more stringent emission standards sooner than other classes of heavy-duty diesel engines; hence, they have been required to certify to a 4.0 g/bhp-hr NOx standard and a 0.05 g/bhp-hr PM standard since 1996. While ARB regulates other pollutants, NOx and PM are the criteria pollutants of primary concern from diesel engines.

In 1997 and 1998 respectively, U.S. EPA and ARB adopted more stringent requirements for 2004 and later model year heavy-duty diesel engines and vehicles. These requirements harmonized the California and federal programs, while maintaining unique aspects of California's program to ensure maximum emission benefits throughout the State. Both programs include a NOx plus non-methane hydrocarbons (NMHC) emission standard of 2.4 g/bhp-hr, or 2.5 g/bhp-hr with a 0.05 g/bhp-hr NMHC cap.

The 2004 requirements did not affect PM emissions, thus the 0.10 g/bhp-hr PM standard for heavy-duty diesel engines, exclusive of urban bus engines, remains in place until 2007 when new heavy-duty diesel engines are required to cut PM exhaust emissions by 90 percent. ARB's urban bus regulation requires urban bus engines to reduce PM emissions even sooner – starting October 1, 2002, diesel-fueled urban bus engines must comply with a 0.01 g/bhp-hr PM standard (this regulation is discussed in more detail later in this chapter).

In December 2000, the ARB adopted regulations that will reduce emissions of NMHC and NOx from heavy-duty gasoline engines from the current 4.0 g/bhp-hr standard to 1.0 g/bhp-hr, beginning with the 2005 model year. This action harmonized California's standards with the federal requirements adopted by U.S. EPA in July 2000. In 2001, U.S. EPA finalized a rule implementing more stringent emission standards for 2008 and later model year on-road heavy-duty gasoline engines and vehicles – lowering the 1.0 g/bhp-hr NMHC+NOx standard to 0.14 g/bhp-hr NMHC and 0.2 g/bhp-hr NOx. In 2002, ARB adopted regulations to harmonize California's standards with the new federal standards.

b. 2004 Standards "Pull-Ahead"

Heavy-duty engines are currently certified on engine dynamometers using a driving cycle known as the Federal Test Procedure (FTP). The FTP mimics the light loads and low speeds typical of urban driving. The high speed, high load operating conditions typical of on-highway heavy-duty trucks are not well represented on the FTP.

Subsequent to the adoption of the 2004 standards, U.S. EPA, ARB, and the Department of Justice discovered that seven large manufacturers of heavy-duty diesel engines had, throughout the late 1980s and 1990s, violated emissions regulations by designing engines with advanced computer controls that maximized fuel economy during steady-state operation, significantly increasing NOx emissions from heavy-duty diesel trucks during typical on-highway driving. Thus, over a million heavy-duty diesel engines manufactured over a period of nearly ten years produced NOx emissions in excess of what would be expected from the FTP. These excess NOx emissions are commonly referred to as “off-cycle” emissions.

To address these emissions violations, U.S. EPA, ARB, and the Department of Justice signed Consent Decrees, legally-binding agreements, with seven engine manufacturers requiring them to partially mitigate their violations and to take corrective action to ensure that future new engines did not produce off-cycle emissions. The key provision of the Consent Decree is the requirement for the majority of affected engine manufacturers to begin producing engines meeting the NOx plus NMHC standards for 2004 and later model year engines starting on October 1, 2002 – over one year ahead of when originally required by U.S. EPA and ARB.

Another key provision of the Consent Decrees is the requirement for affected engine manufacturers to produce engines that meet supplemental test procedures known as the Not-To-Exceed (NTE) test and the EURO III European Stationary Cycle (ESC) test. These supplemental test procedures are more representative than the FTP of the real world driving conditions of on-highway heavy-duty trucks. Together with the FTP, the NTE and ESC tests will help ensure that off-cycle emissions are eliminated in new engines.

c. Not-To-Exceed and EURO III European Stationary Cycle Test Procedures

Recognizing the need for including the supplemental tests in the existing federal engine certification process, U.S. EPA adopted a rule in October 2000 reaffirming the 2004 standards, and also including the use of the supplemental test procedures[1]. However, because of federal timing constraints, the NTE and ESC test procedures will not be required until 2007 for federally certified heavy-duty diesel engines. Therefore, when Consent Decree requirements expire in 2004, heavy-duty diesel engines produced for sale throughout the nation will not be obligated to comply with the requirements of the supplemental test procedures in 2005 and 2006.

[1] U.S. EPA’s 2004 Final Rule on the Control of Emissions of Air Pollution from 2004 and Later Model Year Heavy-Duty Highway Engines and Vehicles; Revision of Light-Duty On-Board Diagnostics Requirements (65 FR 59896, October 6, 2000). Referred to as U.S. EPA’s 2004 Final Rule or 2004 Final Rule.

To ensure that there would not be a disruption in the implementation of the supplemental test procedures on heavy-duty diesel engines produced for sale in California, ARB adopted amendments in December 2000 requiring manufacturers of engines produced for sale in California to comply with the NTE and ESC test procedures for 2005 and later model year engines. Urban bus engines are not required to submit to testing under the supplemental procedures until the 2007 model year. Other states have already exercised their authority under the Clean Air Act to adopt California's more rigorous emission requirements and thus have adopted ARB's NTE limits for on-road heavy-duty diesel engines and vehicles starting with the 2005 model year.

d. New Emission Standards for Urban Bus Engines and the Public Transit Bus Fleet Rule

Heavy-duty diesel engines used in urban buses with GVWRs greater than 33,000 pounds have historically been regulated separately from other heavy-duty diesel engines. In February 2000, the Board adopted a comprehensive urban bus regulation that includes more stringent emission standards for urban bus engines produced for sale in California, and a fleet rule affecting California's public transit bus operators. The regulation requires new diesel urban bus engines to meet a 0.01 g/bhp-hr PM standard in October 2002; an intermediary 0.5 g/bhp-hr NOx standard in 2004, and a near-zero 0.2 g/bhp-hr NOx standard in 2007, equivalent to the NOx standard adopted by U.S. EPA and by ARB for other heavy-duty diesel engines beginning with the 2007 model year. The regulation also requires both diesel and alternative-fuel urban bus engines to comply with more stringent ROG, CO, and formaldehyde emission standards beginning in 2007.

The fleet rule component of the regulation is designed to encourage the use of alternative-fuel buses and contains multiple strategies to reduce emissions from the existing diesel bus fleet. Incorporating regulatory amendments adopted by the Board in October 2002, the fleet rule strategies include: 1) a phased-in diesel PM reduction requirement beginning in 2004; 2) a requirement to use low-sulfur diesel fuel (diesel fuel with a sulfur content no greater than 15 parts per million by weight [ppmw]), or any other fuel verified by our Executive Officer for use as a diesel emission control strategy, beginning July 2002; and 3) a requirement for public transit fleets to achieve and maintain a 4.8 g/bhp-hr NOx average by October 2002. The most innovative and technology-advancing elements of the fleet rule are its requirements for zero emission bus demonstration projects in 2003 and zero emission bus purchases starting in 2008.

An outgrowth of the urban bus regulation is the Board's recognition of heavy-duty vehicle hybrid-electric technology as a viable option for providing emission benefits now – not just as a future technology for reducing emissions. Recent analyses indicate that hybrid-electric heavy-duty vehicles offer improved fuel economy and emit less criteria pollutants than their conventional heavy-duty vehicle counterparts. Urban transit buses, as well as delivery trucks, are particularly good candidates for hybridization, as the diesel engine is not necessary for power in many stop-and-go drive cycles, and regenerative braking during frequent stops will charge the battery system. Through months of coordination between ARB staff and stakeholders, the staff developed the "Interim Certification Procedures for 2004 and Subsequent Model Year Hybrid-Electric Vehicles, in the Urban Bus and Heavy-Duty Vehicle Classes." The Board approved the certification procedures on October 24, 2002.

e. Heavy-Duty Vehicle Inspection and Periodic Smoke Inspection Programs

Because trucks and buses may last 500,000 miles to over one million miles before their engines are rebuilt or replaced, in-use emissions and their potential to increase over time are a critical issue. California currently has two programs designed to control smoke emissions from existing heavy-duty vehicles and to detect malmaintenance and tampering that can increase emissions of any regulated pollutant.

Under the first program, the Heavy-Duty Vehicle Inspection Program (HDVIP), heavy-duty diesel trucks and buses are tested for excessive smoke emissions with a hand-held electronic smoke meter. The smoke opacity test procedure was developed by the Society of Automotive Engineers and adopted by the Board in 1997 for use in the HDVIP and the Periodic Smoke Inspection Program. The smoke opacity cannot exceed 55 percent for pre-1991 model year engines, and cannot exceed 40 percent for 1991 and later model year engines. Vehicles with engines that exceed these smoke standards must be repaired; those with especially high smoke must also pay a monetary penalty. Under the HDVIP, both diesel and gasoline heavy-duty vehicles are inspected for tampering by ARB inspectors at California Highway Patrol facilities, weigh stations, and at random roadside locations. While only heavy-duty diesel vehicles are tested for excessive smoke emissions under the program, both gasoline and diesel heavy-duty vehicles are inspected for tampering, which affects a vehicle's overall emissions performance.

The second program, the Periodic Smoke Inspection Program (PSIP), complements the HDVIP by requiring California-based truck and bus fleets with two or more heavy-duty diesel vehicles to annually test their own vehicles to measure smoke opacity and to check for tampering. The smoke opacity test procedure and standards are identical to those in the HDVIP.

f. 2007 and Later Model Year Emission Standards

In January 2001, U.S. EPA finalized its rule for new emission standards for 2007 and later model year on-road heavy-duty diesel engines and vehicles.[2] U.S. EPA also adopted minor changes to its requirements for the supplemental test procedures, including the Not-to-Exceed and EURO III European Stationary Cycle tests. In October 2001, ARB approved regulatory amendments to align California's emission standards and supplemental test procedure requirements with the 2007 federal requirements.

The 2007 standards break new ground by setting emission standards that require aftertreatment-based technologies for all classes of heavy-duty diesel engines and vehicles. The adopted standards will reduce exhaust emissions from new diesel-cycle engines meeting the 2004 standards by 90 percent for NOx, 72 percent for NMHC, and 90 percent for PM. These emission standards, which are also applicable to both natural gas-fueled engines and liquefied petroleum gas-fueled engines derived from the diesel-cycle engine, are shown in Table II-B-4 below. U.S. EPA adopted the requirements for heavy-duty gasoline-fueled engines (with implementation starting in 2008) at the same time it adopted emission standards for 2007 and later model year heavy-duty diesel engines. ARB adopted regulations to harmonize with the federal standards in 2002.

The Board approved the same phase-in schedules for the NOx and NMHC emission standards as adopted by U.S. EPA. The phase-in schedules, shown in Table II-B-4, represent the percentage of new engines produced for sale in California that are required to meet the more stringent emission standards beginning in 2007. Full implementation is required starting with the 2010 model year.

Table II-B-4
Exhaust Emission Standards for 2007 and Later Model Year Heavy-Duty Diesel Engines/Vehicles

Pollutant	Standard (g/bhp-hr)	Phase-In by Model Year **			
		2007	2008	2009	2010
NOx	0.20	50%	50%	50%	100%
NMHC	0.14	50%	50%	50%	100%
PM10	0.01	100%	100%	100%	100%

** Represents percent of sales

[2] U.S. EPA's 2007 Final Rule on the Control of Emissions of Air Pollution from 2007 and Later Model Year Heavy-Duty Highway Engines and Vehicles; Revision of Light-Duty On-Board Diagnostics Requirements (66 FR 5002, January 18, 2001). Referred to as U.S. EPA's 2007 Final Rule or 2007 Final Rule.

Other components of U.S. EPA's regulation for the 2007 standards are a requirement for the control of crankcase emissions from turbocharged heavy-duty diesel engines, and a requirement to cap the sulfur content of diesel fuel for on-road vehicles at 15 ppmw. ARB regulation includes the requirement for the control of crankcase emissions. ARB approved amendments to California's diesel fuel specifications to cap the sulfur content at 15 ppmw in July 2003, with implementation beginning in 2006. Low-sulfur diesel fuel is necessary to ensure that the advanced emission control devices expected to be used to meet the 2007 standards achieve and maintain maximum efficiency and durability levels.

Of note is that U.S. EPA's rule is applicable to heavy-duty vehicles with GVWRs from 8,501 pounds to 14,000 pounds. However, ARB's adopted regulation is mandatory only for those heavy-duty vehicles with GVWRs greater than 14,000 pounds. In California, vehicles with GVWRs of 8,501 pounds to 14,000 pounds, and engines used in those vehicles, have been regulated through ARB's medium-duty vehicle requirements starting with the 1995 model year. Under these requirements, vehicles with GVWRs of 8,501 pounds to 14,000 pounds are required to chassis certify to applicable emission standards for medium-duty vehicles, or, as an option, engine manufacturers may choose to certify the engines in these vehicles to California's heavy-duty engine emission standards. Engine manufacturers are opting to certify virtually all of their diesel engines used in vehicles with GVWRs of 8,501 pounds to 14,000 pounds to the heavy-duty diesel engine standards; hence, these engines will be subject to the 2007 standards and will benefit from the improved emission control.

3. Proposed Measures

Table II-B-5 provides a summary of measures ARB staff will be proposing over the coming years to enhance California's current control program for on-road heavy-duty diesel engines and vehicles. These measures, when implemented, will achieve further emission reductions from the heavy-duty diesel vehicle fleet. Each measure is described in more detail below.

Table II-B-5
Proposed Measures for On-Road Heavy-Duty Diesel Vehicles

Measures	Timeframe	
	Action	Implementation
ON-RD HVY-DUTY-1: Augment Truck and Bus Highway Inspections with Community-Based Inspections	2003	2005
ON-RD HVY-DUTY-2: Capture and Control Vapors from Gasoline Cargo Tankers	2005	2006-2007
ON-RD HVY-DUTY-3: Pursue Approaches to Clean Up the Existing and New Truck/Bus Fleet	2003-2006	2004-2010

a. ON-RD HVY-DUTY-1: Augment Truck and Bus Highway Inspections with Community-Based Inspections

Time Frame: Action 2003; Implement 2005

Responsible Agency: ARB

Proposed Strategy:

Proper engine maintenance, including maintaining manufacturers' original engine specifications, is critical to ensuring that in-use heavy-duty diesel engines do not exceed established engine standards. As already discussed, the current roadside Heavy-Duty Vehicle Inspection Program is designed to detect malmaintenance and tampering that affect in-use emissions, and to specifically measure smoke emissions to ensure compliance with Board-approved smoke opacity limits.

To complement the traditional Heavy-Duty Vehicle Inspection Program, in March 2001, ARB staff began participating in a new program of focused environmental inspections in existing mixed-use communities (residential/commercial/industrial areas). Under this program, heavy-duty vehicles are inspected to detect malmaintenance and tampering, and to measure smoke emissions, all in concert with fuel inspections and hazardous waste transport inspections. These environmental inspections are implemented in coordination with the California Highway Patrol and local law enforcement agencies.

Diesel emissions are a significant component of the health risk in mixed-use communities. Because of the juxtaposition of residential, commercial and industrial areas, minimizing and further reducing emissions from heavy-duty diesel trucks is necessary to protect the health and safety of the residents and workers in these areas.

The ARB staff has participated in about two environmental inspections per month. Based on ARB's analysis, failure rates are higher for environmental inspections than the traditional inspections. Therefore, ARB intends to reallocate existing resources in order to double the number of environmental inspections performed each month.

Table II-B-6 presents a preliminary estimate of the additional emission reductions that could be achieved.

Table II-B-6
ON-RD HVY-DUTY-1: Augment Truck and Bus Highway Inspections with Community-Based Inspections
Estimated Additional Emission Reductions
(South Coast, Summer Planning, tpd)

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
ROG	0.0 – 0.1	0.0 – 0.1	0.0 – 0.1	0.0 – 0.1	Not Applicable
NOx	0	0	0	0	
PM10	0.0 – 0.1	0.0 – 0.1	0.0 – 0.1	0.0 – 0.1	

SIP Commitment for Measure ON-RD HVY-DUTY-1

South Coast 2003 SIP Commitment:

ARB staff proposes to implement this measure beginning in 2003. The measure will, at a minimum, achieve between 0 and 0.1 tpd ROG reductions in the South Coast Air Basin in 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

b. ON-RD HVY-DUTY-2*:* Capture and Control Vapors from Gasoline Cargo Tankers

Time Frame: Adopt 2005; Implement 2006-2007

Responsible Agency: ARB

Proposed Strategy:

Gasoline cargo tanks are sealed containers coupled with heavy-duty diesel fueled trucks. These vessels are equipped with a vapor recovery system that returns and collects gasoline vapor during the loading at terminals or bulk plants and unloading at service stations respectively. The tanks also include valves and fittings to prevent the loss of vapor during transport.

In 1998, about 4,500 fuel cargo tankers transported over 14 billion gallons of gasoline on California's roadways. These trucks utilize hoses and fittings during the transfer process of delivering gasoline and collecting gasoline vapor. Currently, they do not employ control technologies to reduce ROG emissions that occur through the evaporation of gasoline from the transfer hoses and connections on the tanks after the delivery is completed. ARB staff is now considering a proposal for enhanced vapor recovery systems for gasoline cargo tankers to reduce these ROG losses. The staff plans to present the proposal to the Board in 2005 for implementation beginning in 2006 or 2007.

The control technology necessary to implement this measure is currently available. This measure would require the vapor connections on fuel cargo tankers to be fitted with closure devices such as poppeted adapters or manually operated valves, and product and vapor recovery hoses to have poppeted caps or adapters. The measure would also require a monthly inspection and maintenance program to check the vapor connections and hoses on the fuel cargo tankers.

A separate but related measure is the requirement for purging (degassing) the tankers prior to maintenance or repair. Gasoline cargo tanks must undergo annual testing for pressure integrity as a requirement for certification (CP-204). Before this testing can be performed, the cargo tank must first be purged of any residual gasoline vapors, which may skew the results of the pressure testing. The requirement for purging does not however extend to maintenance and repair of gasoline cargo tanks. These events can be a significant source of ROG emissions. This measure would require that cargo tanks be purged using an approved method prior to any maintenance or repair being performed. Currently, there are three methods available by which the tanks can be purged. These current purging (degassing) methods need to be reviewed.

A third element of this measure is the certification of gasoline cargo tank components. Gasoline cargo tanks are required annually to demonstrate compliance with a leak rate standard. The current procedure tests the pressure integrity of the cargo tank vapor recovery system as a whole but does not contain performance specifications or standards for the individual components of the system. This measure would include developing performance specifications and standards for individual components and methodology for testing and certifying these components.

Potential Emission Reductions:

ARB staff's preliminary estimate of the potential ROG emission reductions from these control measures are based on testing fuel cargo tankers with leaking vapor recovery hoses and connections. Initial testing indicates that statewide ROG emissions of about 14 tpd could be reduced by about 80 percent, or by about 11 tpd in 2010 through the implementation of an enhanced vapor recovery strategy for fuel cargo tankers. For the South Coast, staff estimates an emission inventory of about 5 tpd and potential reductions of about 4 tpd in 2010. As these measures are further developed through ARB's public rulemaking process, the emission estimates will be refined.

SIP Commitment for Measure ON-RD HVY-DUTY-2

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board in 2005. The measure as proposed to the Board will, at a minimum, achieve between 4 and 5 tpd of ROG reductions in the South Coast Air Basin in 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

c. ON-RD HVY-DUTY-3: Pursue Approaches to Clean Up the Existing and New Truck/Bus Fleet – PM In-Use Emission Control, Engine Software Upgrade, On-Board Diagnostics, Manufacturers' In-Use Compliance, Reduced Idling

Time Frame: Adopt 2003-2006; Implement 2004-2010

Responsible Agency: ARB

Proposed Strategy:

New engine standards, together with compliance and enforcement programs designed to ensure that new engines maintain their low emission levels, will provide significant reductions over time. In addition to implementing programs that target new engines and vehicles, ARB must also focus its efforts on reducing emissions from the existing heavy-duty diesel vehicle fleet in order to improve air quality and benefit public health in the near-term. The measures discussed here form a comprehensive strategy to reduce harmful emissions from both the new and in-use heavy-duty vehicle fleet and to ensure that ARB's heavy-duty vehicle program achieves maximum emission benefits.

In 1998, ARB revised the South Coast SIP to replace measure M7, Accelerated Retirement of Heavy-Duty Vehicles, with measure M17, In-Use Reductions from Heavy-Duty Vehicles. M17 described two strategies to reduce emissions from in-use heavy-duty vehicles – incorporating NOx screening into existing roadside smoke inspection to identify malmaintained vehicles for repair and developing an in-use compliance testing and recall program (including the potential use of on-board diagnostic systems). The measure also included market-based incentives as a supplement to ensure that the emission reduction commitments in M17 were met. U.S. EPA has not approved this SIP revision. Since 1998, ARB staff has investigated the two strategies described in M17. Results from field tests indicate that repairing malmaintained heavy-duty engines is not an effective strategy – sometimes leading to post-repair <u>increases</u> in NOx emissions. ARB staff believes that engine software upgrades (described below) are a more effective means of reducing emissions from trucks that are already on the road. ARB staff is continuing to pursue programs aimed at requiring on-board diagnostic systems and in-use vehicle testing. These programs are incorporated into this measure.

PM In-Use Emission Control Fleet Rules: In February 2000, ARB adopted a fleet rule that requires public transit operators to aggressively reduce emissions from their bus fleets. The use of verified diesel emission control strategies to reduce PM emissions is an important part of the transit bus rule. As called for in the Diesel Risk Reduction Plan, which was adopted by the Board in September 2000, ARB intends to expand its opportunities to achieve PM reductions, and in most cases, ROG reductions, through the implementation of additional rules targeting specific heavy-duty diesel fleets.

Like other ARB regulations, the fleet rules will not prescribe the emission control strategies that fleet operators must use. The strategies that operators select, however, must have ARB-verified emission reductions or involve the use of ARB-certified engines, and must meet the emission reduction targets specified by the fleet rules. There are a variety of strategies that fleet operators could potentially use to reduce PM emissions, such as the installation of a hardware-based retrofit system (e.g., a diesel particulate filter) or the use of an alternative diesel fuel. Such retrofit-based strategies would have to be verified by ARB staff using ARB's Diesel Emission Control Strategy Verification Procedure. Fleet operators may also elect to replace older, dirtier engines with new, certified ones (engine repower), retire old vehicles, or replace vehicles with new, lower-emission models. Depending on the strategy chosen by fleet operators, the use of low-sulfur diesel fuel may be an integral strategy component. For example, most catalyst-based diesel particulate filters provide the greatest emission reductions when used with low-sulfur diesel fuel (sulfur content of 15 ppmw or less).

As part of ARB's Diesel Emission Control Strategy Verification Procedure, ARB adopted a multi-level approach for categorizing strategies based on their verified PM emission reductions. For example, "Level 1" verification applies to strategies that achieve at least a 25 percent PM reduction; "Level 2" verification applies to strategies that achieve at least a 50 percent PM reduction; and "Level 3" verification applies to strategies that achieve at least an 85 percent PM reduction, or reduce exhaust PM levels to no more than 0.01 g/bhp-hr. Together with regulations that will require the use of retrofits or other strategies verified to the highest level possible, this multi-level approach ensures the development of high-efficiency control strategies. At the same time, it allows for lower level reductions in applications where higher level options are not yet available, thus ensuring that diesel PM emissions are reduced in a timely manner when and where they can be realized.

The PM fleet rules are intended to provide a flexible and progressive-in-use emission control program that achieves the highest level of PM emission control possible. Although PM reductions are the focus of the rules, staff expects ROG reductions to be realized as well. The currently verified diesel particulate filters, for instance, achieve ROG reductions commensurate with the level of PM reductions achieved.

Table II-B-7 presents staff's estimate of the range of emission benefits for the South Coast Air Basin that would be achieved through implementation of the fleet rules.

Table II-B-7
ON-RD HVY-DUTY-3: Pursue Approaches to Clean Up the Existing and New Truck/Bus Fleet: PM In-Use Emission Control
Estimated Emission Reductions
(South Coast, Summer Planning, tpd)

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
ROG	0.04 – 0.09	0.09-0.3	0.8 – 2.6	1.4 – 4.5	0.5 – 1.7
NOx	Not Quantified				
PM10	0.02 – 0.04	0.03 – 0.2	0.2 – 1	0.4 – 1.6	0.2 – 0.5
CO	Not Quantified			6-18	NQ

Engine Software Upgrade: ARB staff is proposing to require the installation of low NOx software in heavy-duty diesel vehicles with 1993 through 1998 model year engines for which low NOx software was developed under the Consent Decrees. The installation of low NOx software is also known as engine recalibration, chip reflash or engine software upgrade. In this procedure, the engine's electronic control module (ECM) is reprogrammed to reduce NOx emissions from levels achieved during typical in-use driving conditions.

Prior to installing low NOx software, the 1993 through 1998 model year engines emit "off-cycle" NOx. Off cycle NOx are emissions greater than the emissions allowed in the engine certification process; these off-cycle emissions occur when the ECM recognizes that the engine is not being driven in accordance with the federal test procedure used for engine certification.

Upgrading the software on a heavy-duty diesel engine's ECM provides opportunities to reduce NOx emissions. To comply with the Low NOx Rebuild Program contained in the federal Consent Decrees and similar state Settlement Agreements, engine manufacturers were required to provide engine dealers and distributors with low NOx rebuild kits to reduce the off-cycle emissions from specified engines. Under the provisions of the Consent Decrees, these kits implement certain software and/or minor hardware changes to achieve the necessary NOx reductions. To date, the available low NOx rebuild kits have relied only on engine software upgrades; the kits have not included hardware changes. In general, the engine software upgrade reduces NOx emissions by eliminating advanced computer controls – "defeat devices" – that produce excess off-cycle NOx emissions during steady-state vehicle operation, such as on-highway driving.

When the Consent Decrees were signed, it was assumed that the low NOx rebuild kits would be installed at the time of normal engine rebuild, typically around 200,000 to 300,000 miles of service. The engine manufacturers have complied with the provisions of the Low NOx Rebuild Program requiring them to provide dealers and distributors with low NOx rebuild kits (i.e., engine software upgrade kits). ARB staff, however, estimates that only four to ten percent of the low NOx rebuild kits have been installed in applicable engines. As diesel engines have become increasingly durable, fewer rebuilds are being performed or are performed at higher mileage intervals. As such, the Low NOx Rebuild Program has not yet achieved its expected emission benefits.

The ARB staff believes that off-cycle NOx emissions should be eliminated now. To ensure that emission benefits are achieved, ARB staff will propose to the Board in October 2003 a mandatory heavy-duty diesel engine software upgrade measure to reduce NOx emissions. We estimate that there are about 100,000 California-registered heavy-duty diesel vehicles with engines eligible for the software upgrades. Implementation of this measure would begin in 2004. This measure would expand upon the original requirements of the Low NOx Rebuild Program by requiring the installation of software upgrades on applicable engines. The proposed mandatory measure would not require any engine hardware changes. The reductions associated with this proposed measure are necessary to mitigate a portion of the off-cycle emissions that occurred due to the use of "defeat devices."

Table II-B-8 below shows the estimated NOx reductions that could be achieved through the implementation of a mandatory engine software upgrade measure. These reduction estimates are based on the assumption that software upgrades are installed on all applicable 1993 through 1998 model year heavy heavy-duty diesel and medium heavy-duty diesel engines in vehicles registered in California. The estimates presented below were calculated using confidential emissions data obtained during the Consent Decree negotiations, and VMT estimates provided by the Southern California Association of Governments. ARB staff intends to propose that engines in heavy-duty diesel vehicles registered out of state also be subject to this regulatory measure; the staff is now in the process of finalizing any additional emission benefits that may be achieved.

Table II-B-8
ON-RD HVY-DUTY-3: Pursue Approaches to Clean Up the Existing and New Truck/Bus Fleet:
Mandatory Engine Software Upgrade
Estimated Emission Reductions for MHDDE and HHDDE California Registered Trucks
(South Coast, Summer Planning, tpd)

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
NOx	13 - 17	12 - 16	11 -14	8 - 10	0 - 1

On-Board Diagnostics (OBD): As ARB implements more stringent emission standards, engine manufacturers are incorporating into their engine designs more sophisticated emission control devices such as exhaust gas recirculation systems, fuel injection rate shaping techniques, particulate filters, NOx adsorbers, and other electronic controls. To maintain low emission levels over time, these emission control devices must continue to perform properly throughout each vehicle's life.

One strategy to ensure that sophisticated emission controls perform adequately over time is to require a comprehensive OBD system on all heavy-duty vehicles. The current diagnostic systems voluntarily implemented by manufacturers are designed primarily to detect gross failures of components (e.g., disconnections and other circuit failures, rather than deterioration or reduced performance) without regard to the emission level associated with the malfunction. The measure proposed here would require OBD systems to detect malfunctions of virtually every component that can cause an emission increase before the emissions exceed a specified level. While discussed here primarily as a heavy-duty diesel engine strategy, it would also apply to heavy-duty gasoline engines used in vehicles with a GVWR greater than 14,000 pounds.

The comprehensive OBD system would alert the vehicle operator of the malfunction through a dashboard light; valuable information about the malfunction would be stored in the on-board computer to assist technicians in diagnosing and repairing the malfunction. As with light-duty vehicles, an OBD system for heavy-duty vehicles would likely not require the addition of many new sensors or components. Instead, the OBD system would consist primarily of software in the existing on-board computer and would use many of the existing engine and emission control sensors.

Because the heavy-duty vehicle fleet is predominantly diesel-fueled, the benefits of an OBD program would primarily be associated with heavy-duty diesel vehicles with GVWRs greater than 14,000 pounds. Nonetheless, the potential OBD strategy would also apply to gasoline heavy-duty vehicles with GVWRs greater than 14,000 pounds, and would also provide additional emission benefits from heavy-duty gasoline vehicles.

ARB staff is working closely with U.S. EPA on developing an OBD program for heavy-duty engines and vehicles. ARB staff expects to present a proposal to the Board in the 2003 to 2004 timeframe with implementation beginning in 2007. Because many trucks in interstate commerce are registered outside of California, it is also necessary for U.S. EPA to adopt the same regulatory requirements. We expect U.S. EPA adoption in 2004 with federal implementation also beginning in 2007.

Manufacturer-Required In-Use Vehicle Testing: This proposed measure would require manufacturers of heavy-duty diesel engines to test a specific number of engines per engine family by procuring and testing in-use vehicles at various mileage intervals. The responsibility for procuring and testing vehicles would be on the engine manufacturers, not on ARB. If the vehicles tested do not meet applicable emission standards, the engine manufacturer may be required to test additional vehicles to determine if an engine recall is required. This program component may also include mechanisms to streamline the engine certification process in order to ease engine manufacturers' testing burden. ARB is working closely with U.S. EPA to develop this measure. ARB staff expects to propose this measure to the Board in 2004, the same timeframe in which U.S. EPA is expected to adopt an in-use compliance program. Beginning in 2005, a pilot program in California will be used to generate data and gain experience in testing heavy-duty diesel engines on-road with on-board measurement systems. A fully implemented and enforceable manufacturer-run in-use compliance program for both ARB and U.S EPA will begin in 2007.

Reduced Truck and Bus Idling: To date, ARB's heavy-duty emission control program has focused on engine emission standards without specifically targeting idling emissions. Nonetheless, ARB staff recognizes that idling emissions pose a serious air quality and health threat, particularly at warehouse/distribution centers located in areas that may already be disproportionately impacted by pollution, or at school bus stops populated by young children who are particularly sensitive to the impacts of pollution.

During idle operations, heavy-duty vehicles consume large amounts of diesel fuel, increase emissions, and produce noise. While idling practices vary among truck drivers by season and geographic location, a study by the Argonne National Laboratory indicates that long-haul trucks in the United States idle between five hours and ten hours per day, depending on the season. This same study also estimates that the average heavy-duty long-haul truck idles about six hours per day for 303 days annually[3]. When resting or sleeping, truck drivers may keep the engine running at idle to heat or cool the sleeper and/or cab, and to provide power to operate on-board appliances such as refrigerators, microwaves, television sets, and laptop computers. Heavy-duty trucks are also typically operated at idle to keep the engine block and diesel fuel warm for easy start-up during the winter months.

Some proactive trucking firms implement their own voluntary restricted-idling programs, and certain cities and municipalities already enforce ordinances that prohibit extended idling. ARB staff is now developing measures expanding upon these local efforts to reduce idling emissions from both new and in-use heavy-duty diesel vehicles.

<u>New Vehicles</u>: For new vehicles, ARB staff plans to present to the Board a proposal in the 2003-2004 timeframe that would require idle-limiting devices on California-registered new heavy heavy-duty vehicles (diesel vehicles with GVWRs

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[3] Stodolsky, F.; Gaines, L.; Vyas, A. *Analysis of Technology Options to Reduce the Fuel Consumption of Idling Trucks*; Argonne National Laboratory; ANL/ESD-43. June 2000.

greater than 33,000 pounds) starting with the 2007 model year. These vehicles are typically used in line haul service and provide the greatest opportunities for reductions in idling emissions. The idle-limiting devices could range from systems that automatically shut down an engine after a specific time, to stop/start systems that automatically stop and start the engine as necessary to maintain engine and cab temperature and battery voltage within pre-set limits. Different idle-limiting technologies would be fully evaluated during ARB's public process for regulatory development. This regulatory strategy could also incorporate the use of alternative power systems, such as auxiliary power units, thermal storage systems, and truck stop electrification, to supply power for cab and on-board appliance functions as necessary.

Based on staff estimates, NOx emissions would be reduced by less than one ton per day in the SCAB in 2010. This estimate is based on the assumption that the average idling time for a heavy heavy-duty diesel truck would be reduced by 25 percent to 50 percent through the use of an idle-limiting device.

In-Use Vehicles: ARB in December 2002 adopted an Airborne Toxic Control Measure (ATCM) to reduce idling emissions from school buses, thereby reducing toxic diesel PM and other associated toxic air contaminants. The ATCM also includes provisions to limit idling from other heavy-duty vehicles operating near and on school grounds. While the ATCM provides some modest emission benefits that would reduce region-wide exposure to unhealthful exhaust emissions, the main purpose of the measure is to reduce localized exposure to diesel PM and other toxic air contaminants in the vicinity of schools.

To address heavy-duty vehicles operating at locations other than schools, ARB staff also plans to conduct an assessment to identify possible approaches for reducing diesel PM emitted from heavy-duty trucks and transit buses during idling operations. ARB staff plans to complete this assessment by the end of 2003. This assessment would examine the magnitude of current and future idling emissions, the level of human exposure, and possible approaches for reducing idling emissions. Staff would examine a wide range of approaches. Approaches to be examined would include operator education programs, public information, and fleet operator training programs. Additional approaches to be examined would include local ordinances restricting idling, no-idle zones, and requiring idle-limiting devices for certain fleets. Development of an airborne toxic control measure would be pursued to implement the regulatory aspects of this effort.

Alternatively, ARB staff may consider the feasibility of a legislative approach to restrict heavy-duty vehicles throughout the State from idling for extended time periods at loading docks, bus stops, and other areas where idling emissions occur. Similar to the regulatory approach, this strategy would restrict idling at various sources, thus reducing toxic diesel PM emissions and other associated toxic air contaminants.

Table II-B-9 shows the estimated emission benefits from all the approaches in this measure in the San Joaquin Valley.

Table II-B-9
ON-RD HVY-DUTY-3: Pursue Approaches to Clean Up the Existing and New Truck/Bus Fleet – PM In-Use Emission Control, Engine Software Upgrade, On-Board Diagnostics, Manufacturers' In-Use Compliance, Reduced Idling
Estimated Emission Reductions
(San Joaquin Valley, Winter Planning, tpd)

Pollutant	2010
ROG	1.5
NOx	4
PM10	0.1

SIP Commitment for Measure ON-RD HVY-DUTY-3

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board between 2003 and 2006. The measure as proposed to the Board will, at a minimum, achieve between 1.4 and 4.5 tpd of ROG reductions and between 8 and 11 tpd of NOx reductions in the South Coast Air Basin in 2010.

San Joaquin Valley 2003 PM10 SIP Commitment:

On June 26, 2003, the Board approved State commitments for the San Joaquin Valley's PM10 SIP. ARB staff commits to bring this measure to the Board between 2003 and 2006. Emission reductions from this measure will be used toward meeting ARB's commitment to adopt new measures between 2002 and 2008 that reduce emissions by an additional 10 tpd NOx and 0.5 tpd direct PM10 in the San Joaquin Valley by 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

4. Long-Term Advanced Technologies Measures

In addition to the specific proposed measures discussed in this chapter, there are other strategies that may yield further emission reductions from the on-road heavy-duty diesel vehicle fleet. For example, continued funding for ARB's Carl Moyer Program and Lower-Emission School Bus Program would provide for the introduction of cleaner heavy-duty vehicle technologies and reduce in-use emissions. These are examples of successful incentive programs, but their future success depends directly on the availability of State funding. Additional NOx reductions could be achieved with the installation of NOx retrofit technologies such as selective catalytic reduction systems or NOx adsorbers – once these or other NOx retrofit technologies are verified through ARB's Diesel Emission Control Strategy Verification Procedure. Other long-term advanced technology measures include the use of alternative diesel fuels such as emulsified diesel fuels or biodiesel, and the introduction of extremely low-emitting alternative-fuel engines and fuel cells for heavy-duty vehicles.

a. Federal Responsibility

On-Board Diagnostics: ARB staff is working closely with U.S. EPA on developing an OBD program for heavy-duty engines and vehicles. ARB staff expects to present a proposal to the Board in the 2003-2004 timeframe with implementation beginning in 2007. Because many trucks in interstate commerce are registered outside of California, it is also necessary for U.S. EPA to adopt the same regulatory requirements. We expect U.S. EPA adoption in 2004 with federal implementation also beginning in 2007.

Manufacturer-Required In-Use Vehicle Testing: ARB is working closely with U.S. EPA to develop this measure. ARB staff expects to propose this measure to the Board in 2004, the same timeframe in which U.S. EPA is expected to adopt an in-use compliance program. Beginning in 2005, a pilot program in California will be used to generate data and gain experience in testing heavy-duty diesel engines on-road with on-board measurement systems. A fully implemented and enforceable manufacturer-run in-use compliance program for both ARB and U.S EPA will begin in 2007.

CHAPTER C

Off-Road Compression-Ignition (Diesel) Engines

CHAPTER C. OFF-ROAD COMPRESSION-IGNITION (DIESEL) ENGINES

1. Category Description

Off-road compression-ignition (CI) engines are diesel engines primarily used in farm, construction, and industrial equipment. In 2000, the California off-road CI engine category included over 450,000 engines, contributing 4 percent of total mobile source baseline ROG emissions, 21 percent of NOx emissions, and 31 percent of PM emissions. By 2020, emissions will be reduced by over 50 percent due to existing control programs. The baseline ROG, NOx and PM emissions from all off-road CI engines, including both preempt and non-preempt, are listed in Table II-C-1.

Table II-C-1
Statewide Off-Road CI Engines
Baseline Emission Inventory
(Annual Average, tpd)

Pollutant	2000	2005	2010	2015	2020
ROG	75	64	48	34	26
NOx	585	511	404	301	244
PM10	39	36	29	23	18

The federal Clean Air Act prohibits California (and other states) from regulating emissions from new engines used in construction and farming equipment less than 175 horsepower. These equipment types are termed “preempted” and represent about 80 percent of the total number of CI engines operating in California. ARB works closely with U.S. EPA and relies heavily on federal action to regulate these engines to obtain needed emission reductions. The remaining equipment is commonly referred to as non-preempt off-road CI engines. Some types of equipment in this category include generators and pleasure craft. Table II-C-2 lists the South Coast baseline emission inventory grouped by non-preempt (ARB regulated) and preempt (U.S. EPA regulated) engines based on summer planning daily emissions. Table II-C-3 shows baseline emissions for the San Joaquin Valley.

Table II-C-2
Baseline Emissions for Off-Road Compression-Ignition (Diesel) Engines
(South Coast, Summer Planning, tpd)

Pollutant	2000		2005		2010		2015		2020	
	ARB	U.S. EPA	ARB	U.S. EPA	ARB	U.S. EPA	ARB	U.S. EPA	ARB	U.S. EPA
ROG	7	15	5	13	4	10	3	7	3	5
NOx	65	100	56	90	44	72	32	53	27	43
PM10	3	8	3	8	2	7	2	5	2	4
CO	27	45	19	45	15	44	13	42	13	42

Table II-C-3
Baseline Emissions for Off-Road
Compression Ignition Engines
(San Joaquin Valley, Winter Planning, tpd)

Pollutant	2010
ROG	7.1
NOx	66
PM10	4.5

2. Existing Control Program

a. Engine Standards

In September 1996, ARB, U.S. EPA, and the diesel engine manufacturers signed a statement of principles (SOP) calling for harmonization of ARB and U.S. EPA off-road CI engine regulations. The SOP is a cooperative agreement between ARB, U.S. EPA, and the engine manufacturers that recognizes the technological feasibility of significant emission reductions from off-road CI engines. The SOP called for new NOx, HC, and PM emission standards that would reduce NOx and PM emissions by more than 60 percent.

In August 1998, U.S. EPA adopted new emission standards, along with changes to the existing federal averaging, banking, and trading program, and changes to useful life and maintenance requirements for off-road diesel engines. In January 2000, ARB adopted amendments to existing California emission standards and test procedures to harmonize as closely as possible with the federal program while still maintaining the emission reduction benefits of the existing California program. These standards consist of a tiered structure of emission limits based on engine power. The federal Tier 1 standards were implemented in 1996 and the Tier 2 standards are being phased-in, beginning in 2001, over the next few years based on each power category. Tier 3 HC+NOx and CO standards were adopted for 50 to 750 horsepower (hp) engines with a phase-in beginning in 2006. Table II-C-4 below summarizes the existing standards applicable to new off-road CI engines sold in the United States.

Table II-C-4
Off-Road Compression-Ignition (Diesel) Engine Standards for New Engines

Rated Power (hp)	Model Year	g/bhp-hr				
		NOx	HC	NMHC +NOx	CO	PM10
<11	2000+	--	--	7.8	6.0	0.75
<11	2005+	--	--	5.6	6.0	0.60
11 to <25	2000+	--	--	7.1	4.9	0.60
11 to <25	2005+	--	--	5.6	4.9	0.60
25 to <50	1999+	--	--	7.1	4.1	0.60
25 to <50	2004+	--	--	5.6	4.1	0.45
50 to <100	2000-2003	6.9	--	--	--	--
50 to <100	2004+	--	--	5.6	3.7	0.30
50 to <100	2008+	--	--	3.5	3.7	--
100 to <175	2000-2002	6.9	--	--	--	--
100 to <175	2003+	--	--	4.9	3.7	0.22
100 to <175	2007+	--	--	3.0	3.7	--
175 to <300	1996-2002	6.9	1.0	--	8.5	0.40
175 to <300	2003+	--	--	4.9	2.6	0.15
175 to <300	2006+	--	--	3.0	2.6	--
300 to <600	1996-2000	6.9	1.0	--	8.5	0.40
300 to <600	2001+	--	--	4.8	2.6	0.15
300 to <600	2006+	--	--	3.0	2.6	--
600 to 750	1996-2001	6.9	1.0	--	8.5	0.40
600 to 750	2002+	--	--	4.8	2.6	0.15
600 to 750	2006+	--	--	3.0	2.6	--
>750	2000-2005	6.9	1.0	--	8.5	0.40
750+	2006+	--	--	4.8	2.6	0.15

b. Carl Moyer Program

The Carl Moyer Program is a heavy-duty diesel engine incentive program designed to obtain early emission reductions of NOx and particulate matter from heavy-duty vehicles and equipment, including those used in off-road applications. Under the program, ARB has the responsibility to establish program guidelines, oversee the program, and report program benefits. Local air districts implement the program and work with the public and private participants. The program provides grants to pay for the extra cost of replacing existing diesel engines with lower-emission engines, including new cleaner diesels, or engines powered by alternative fuels or electricity. The program is successful in providing near-term emission reductions from off-road engines such as those in farm and construction equipment. For the first two years of funding, off-road projects constituted about 60 percent (4 tons per day NOx) of the overall emission reductions from the Carl Moyer Program. An annual funding source is needed in order to rely on incentive programs, similar to the Carl Moyer Program, to provide emission reductions.

3. Proposed Strategies

The measures ARB staff is proposing are listed in Table II-C-5. All listed measures would reduce emissions of ROG, NOx, and diesel PM.

Table II-C-5
Proposed Strategies for Off-Road Compression-Ignition (Diesel) Engines

Strategy	Timeframe	
	Action	Implementation
OFF-RD CI-1: Pursue Approaches to Clean Up the Existing Heavy-Duty Off-Road Equipment Fleet – Retrofit Controls	2004 - 2008	2006 - 2010
OFF-RD CI-2: Implement Registration and Inspection Program for Existing Heavy-Duty Off-Road Equipment to Detect Excess Emissions	2006 - 2009	2010

a. OFF-RD CI-1: Pursue Approaches to Clean Up the Existing Heavy-Duty Off-Road Equipment Fleet – Retrofit Controls [Compression-Ignition Engines]

Time Frame: Adopt 2004-2008; Implement 2006-2010

Responsible Agencies: ARB

New heavy-duty diesel engine standards provide significant, long-term reductions in emissions as the fleet turns over. Compliance and enforcement programs are designed to ensure that new engines maintain their low emission levels. However, to improve air quality and benefit public health in the near-term, emissions from the existing heavy-duty diesel equipment fleet must be reduced.

The strategies discussed here specifically target in-use emissions from the existing fleet. These strategies can provide near-term reductions, depending on when implemented, but can also provide longer-term reductions lasting until each affected vehicle is replaced with a newer vehicle meeting more stringent emission standards.

PM In-Use Emission Control Rules: Verified diesel emission control strategies to reduce PM emissions first appeared in California regulations with the adoption of the transit bus rule by ARB in February 2000. As called for in the Diesel Risk Reduction Plan, which was adopted by the Board in September 2000, ARB intends to expand its opportunities to achieve PM reductions, and in most cases, ROG reductions. These reductions will be accomplished through the implementation of additional rules targeting not only other on-road fleets, but heavy-duty diesel off-road vehicles and equipment as well.

Like other ARB regulations, the in-use emission control rules will not prescribe the emission control strategies that operators of off-road engines must use. The strategies that operators select, however, must have ARB-verified emission reductions or involve the use of ARB-certified engines, and must meet the emission reduction targets specified by the rules. There are a variety of strategies that operators could potentially use to reduce PM emissions, such as installation of a hardware-based retrofit system (e.g., a diesel particulate filter). Such retrofit-based strategies would first have to be verified by ARB staff using ARB's Diesel Emission Control Strategy Verification Procedure. Fleet operators may also elect to replace older, dirtier engines with new, certified ones (engine repower), retire old vehicles/equipment, or replace vehicles/equipment with new, lower-emission models. Depending on the strategy chosen by operators, the use of low-sulfur diesel fuel may be an integral strategy component. For example, most catalyst-based diesel particulate filters provide the greatest emission reductions when used with low-sulfur diesel fuel (sulfur content of 15 ppmw or less).

As part of the Diesel Emission Control Strategy Verification Procedure, ARB adopted a multi-level approach for categorizing strategies based on their verified PM emission reductions. For example, "Level 1" verification applies to strategies that achieve at least a 25 percent PM reduction; "Level 2" verification applies to strategies that achieve at least a 50 percent PM reduction; and "Level 3" verification applies to strategies that achieve at least an 85 percent PM reduction, or reduce exhaust PM levels to no more than 0.01 g/bhp-hr. Together with regulations that will require the use of retrofits or other strategies verified to the highest level possible, this multi-level approach ensures the development of high-efficiency control strategies. At the same time, it allows for lower level reductions in applications where higher level options are not yet available, thus ensuring that diesel PM emissions are reduced in a timely manner when and where they can be realized.

The PM rules are intended to provide a flexible and progressive in-use emission control program that achieves the highest level of PM emission control possible. Although PM reductions are the focus of the rules, the staff expects ROG reductions to be realized as well. The currently verified diesel particulate filters, for instance, achieve ROG reductions proportional to the PM reductions achieved.

In-use emission control programs for off-road vehicles/equipment could be implemented through a variety of approaches. One such approach could require large State construction contracts to include a demonstration of reductions as a contract condition. In addition, an in-use emission control rule for off-road equipment could apply specifically to publicly-owned and contracted fleets. While an off-road in-use emission control program is certainly feasible, its effectiveness may be less than optimum without a statewide registration program. This is because it would be difficult to track certain types of retrofitted off-road equipment, thereby hampering the ability to directly enforce the retrofit installation. Therefore, ARB staff is also considering a proposal for a registration requirement in California for off-road equipment (see measure OFF-RD CI-2).

A likely timeframe for implementing a PM in-use emission control rule for privately-owned off-road vehicles/equipment would be in 2007. By that time, there should already be widespread availability of low-sulfur diesel fuel (sulfur content of 15 ppmw or less), which is necessary for many retrofit technologies to perform effectively and reliably. For publicly-owned or publicly-contracted fleets, however, a phased-in implementation schedule beginning earlier may be considered since California refiners are capable of producing very low sulfur diesel fuel in sufficient quantities for fleet use.

Table II-C-6 below shows the estimated emission benefits in the South Coast Air Basin from implementation of the PM in-use emission control rules. Table II-C-7 shows the estimated benefits in the San Joaquin Valley.

Table II-C-6
OFF-RD CI-1: Pursue Approaches to Clean Up the Existing Off-Road Equipment Fleet – Retrofit Controls
[Compression-Ignition Engines]
Estimated Emission Reductions
(South Coast, Summer Planning, tpd)

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
ROG	n/a	0.03-0.10	0.8-2.8	2.3-7.8	1.3-4.3
NOx	Not Quantified				
PM10	n/a	0.02-0.06	0.6-1.9	1.6-5.4	0.9-3.2
CO	Not Quantified			9-29	NQ

Table II-C-7
OFF-RD CI-1: Pursue Approaches to Clean Up the Existing Off-Road Equipment Fleet – Retrofit Controls
[Compression-Ignition Engines]
Estimated Emission Reductions
(San Joaquin Valley, Winter Planning, tpd)

Pollutant	2010
ROG	1.0
NOx	0
PM10	0.4

SIP Commitment for Measure OFF-RD CI-1

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board between 2004 and 2008. The measure as proposed to the Board will, at a minimum, achieve between 2.3 and 7.8 tpd of ROG reductions in the South Coast Air Basin in 2010.

San Joaquin Valley 2003 PM10 SIP Commitment:

On June 26, 2003, the Board approved State commitments for the San Joaquin Valley's PM10 SIP. ARB staff commits to bring this measure to Board between 2004 and 2008. Emission reductions from this measure will be used toward meeting ARB's commitment to adopt new measures between 2002 and 2008 that reduce emissions by an additional 10 tpd NOx and 0.5 tpd direct PM10 in the San Joaquin Valley by 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

c. OFF-RD CI-2: Implement Registration and Inspection Program for Existing Heavy-Duty Off-Road Equipment to Detect Excess Emissions [Compression-Ignition Engines]

Time Frame: Action 2006-2009; Implement 2010

Responsible Agency: ARB

Proposed Strategy:

As ARB staff develops off-road control measures to reduce in-use emissions (including PM and NOx), registration and inspection programs will be incorporated as a component of each regulation. The most-effective registration and inspection programs would be tailored to the type of equipment, the application, and the type of control proposed. Thus, this strategy would not be an all-encompassing registration and inspection program, but rather would be developed on a measure-by-measure basis, with input from engine and aftertreatment manufacturers, industry, environmental groups, and the public. For PM in-use emission controls like those described in OFF-RD CI-1, the registration and inspection program would help ensure that control equipment is properly installed and functioning as designed by the manufacturer, and that the equipment owner is complying with any equipment or fleet requirements.

Registration and inspection programs are a means of ensuring that the chosen control strategies remain effective over the lifetime of the engine or equipment. Thus, the benefits of registration and inspection programs can be divided into (1) reductions due to detection of failing systems and corrective action, and (2) indirect reductions due to the deterrent effect of the program. The inspection component could include a simplified compliance test that could be performed on-site and correlated to the certification test. The inspection component could also include in-use testing to detect excess emissions. ARB staff has not estimated emission benefits from off-road registration and inspection programs. The benefits are assumed to be included in the estimated benefits from the in-use control strategies.

<u>SIP Commitment for Measure OFF-RD CI-2</u>

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board between 2006 and 2009. We have not quantified benefits for this measure.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

4. Long-Term Advanced Technologies Measures

Additional emission reductions from off-road CI engines can be achieved through the development and implementation of technological advances, availability of financial incentives, or federal action. A number of these approaches are presented in this section.

Emulsified diesel or alternative diesel fuels: The use of emulsified or alternative diesel fuel can provide emission reductions for earlier model year off-road engines, where retrofit controls options are very expensive or can be difficult to implement. Emulsified or alternative diesel fuels used in early model off-road diesel engines can provide NOx emission reductions of about 10 percent and PM emission reductions of about 60 percent. Emission reductions could be realized almost immediately.

Reduced idling from construction equipment: Off-road diesel engines with electronically controlled engines could be programmed to shut down the engine after a set period of free idle. In addition to reducing emissions that occur during extended idling an idle limit device also would provide protection to aftertreatment devices such as diesel particulate filters. Add-on devices such as the Cummins ICON™ Idle Control Systems are currently available to consumers for existing electronically controlled engines and have been used successfully in on-road applications resulting in 0.5 miles per gallon fuel economy improvements, according to the manufacturer.

Blue Skies Series engines: Additional emission reductions from off-road CI engines could be obtained by extending the current voluntary "Blue Sky Series" engine program. The optional emission standards for HC+NOx and PM would be 40 percent lower than the current model year standards.

NOx emission control retrofit technology: Selective catalytic reduction (SCR) technology has been used in stationary sources for over 15 years and is also used in some mobile sources throughout Europe. SCR as a retrofit system has demonstrated a NOx reduction of about 70 percent, PM emissions by about 25 percent and ROG emissions by about 50 to 90 percent. NOx adsorbers operate within the oxygen rich ("lean burn") conditions of diesel engines. The adsorber stores NOx under oxygen rich conditions; an engine management system then determines when NOx adsorption is near saturation and changes engine operation to the fuel rich conditions necessary to release and catalyically reduce to stored NOx. NOx adsorbers require the use of low-sulfur diesel fuel.

Off-Road CI engine fleet upgrade: Replace or upgrade engines in the existing fleet with lower-emitting engines. Upgrade as many pre-Tier 2 engines as possible to bring them into compliance with federal Tier 2 HC+NOx emission standards. For engines where a Tier 2 upgrade is unfeasible, compliance with Tier 1 emission standards could instead be funded. It is estimated that approximately 85 percent of existing Tier 1 engines and 50 percent of uncontrolled engines could be upgraded to Tier 2 HC+NOx standards. It is also estimated that 80 percent of the remaining uncontrolled engines could be upgraded to meet the Tier 1 HC+NOx standards.

a. Federal Responsibility

ARB intends to work closely with U.S. EPA to establish nationwide lower-emission standards for HC, NOx, and PM emissions from new off-road compression ignition engines. A nationwide standard would produce much needed reductions from preempt off-road CI engines that also operate within California.

CHAPTER D

Off-Road Large Spark-Ignition Engines

CHAPTER D. OFF-ROAD LARGE SPARK-IGNITION ENGINES

1. Category Description

The large spark-ignition engine (LSI) category consists of off-road spark-ignition engines greater than 25 horsepower and typically fueled by gasoline or liquefied petroleum gas (LPG). A small number are fueled by compressed natural gas (CNG), and some have dual fuel capability. Emissions from these sources include combustion emissions, such as hydrocarbons (HC), oxides of nitrogen (NOx), carbon monoxide (CO), and particulate matter (PM), as well as evaporative hydrocarbon (HC) emissions. LSI engines are most commonly found in forklifts, specialty vehicles, portable generators, pumps, compressors, farm equipment, and construction equipment. This category excludes marine propulsion engines, engines used in equipment that operate on rails, recreational vehicles, snowmobiles, and gas turbines. U.S. EPA has the sole authority to control new farm and construction equipment engines less than 175 horsepower.

The estimated South Coast 2010 non-preempt LSI engine population is about 33,400. The estimated South Coast 2010 population of federally preempted LSI engines is about 6,400. South Coast summer average emissions from these two LSI populations are listed in Table II-D-1. The decrease in exhaust emissions for non-preempt engines is the result of California standards implemented in 2001. The federally preempted portion of this category accounts for about 20 percent of the estimated 2010 uncontrolled emissions of ozone precursors from LSI engines. Forklifts are a major subcategory – almost 50 percent of the LSI engine population. The forklift population in South Coast Air Basin is estimated to be about 22,600 in 2010. Baseline emissions for the San Joaquin Valley are shown in Table II-D-2.

Table II-D-1
Baseline Emissions for Large Spark-Ignition Engines
ARB (Non-Preempt) vs. U.S. EPA (Preempt)
(South Coast, Summer Planning, tpd)

Pollutant	2005		2006 (Annual Average)		2008		2010		2020	
	ARB	U.S. EPA	ARB	U.S. EPA	ARB	U.S. EPA	ARB	U.S. EPA	ARB	U.S. EPA
ROG	6	1	6	1	5	1	3	1	2	1
NOx	22	3	19	3	15	3	12	3	9	3
PM10	0	0	0	0	0	0	0	0	0	0
CO	106	13	105	12	102	13	94	13	89	14

Table II-D-2
Baseline Emissions for Large Spark-Ignition Engines
(San Joaquin Valley, Winter Planning, tpd)

Pollutant	2010
ROG	5.4
NOx	3.4
PM10	0.2

2. Existing Control Program

a. Engine Standards

To implement 1994 SIP Measure M11, Three-Way Catalyst Technology, ARB adopted the current HC+NOx and CO exhaust emission standards for the non-preempt portion of LSI engines and equipment in October 1998. Staff relied on the expected exhaust emission reductions associated with closed loop, three-way catalyst technology to develop the HC+NOx and CO exhaust emission standards shown in Table II-D-3 below. The adopted 3.0 g/bhp-hr HC+NOx exhaust standard was based primarily on what is achievable with automotive-derived technologies. Staff based the 37 g/bhp-hr CO standard on the CO standard for on-road heavy-duty trucks powered by gasoline. Catalysts have long been used to reduce emissions from off-road spark-ignition equipment in special operating environments such as mines and indoor warehousing applications.

These standards, which are being phased in over four years, institute new engine emission standards beginning with the 2001 model year and are summarized in Table II-D-3. For 2001, 25 percent of LSI engines were required to certify as compliant with the standard and 75 percent could be certified non-compliant engines. Beginning with 2004 models, the same numerical exhaust emission standards for HC+NOx and CO will apply, but manufacturers will be required to certify their engines to a durability period. Beginning with the 2007 model year, this durability period will be 5000 hours, representative of the useful life of the engine.

Table II-D-3
Current ARB Exhaust Emission Standards for Large Spark-Ignition Engines

Model Year	Engine Displacement	Durability Period	HC + NOx	CO
			Grams per brake horsepower-hour [grams per kilowatt-hour]	
2002 and subsequent	≤ 1.0 liter	1,000 hours or 2 years	9.0 [12.0]	410 [549]
2001 – 2003	> 1.0 liter	N/A	3.0 [4.0]	37.0 [49.6]
2004 – 2006**	> 1.0 liter	3,500 hours or 5 years	3.0 [4.0]	37.0 [49.6]
2007 and subsequent	> 1.0 liter	5,000 hours or 7 years	3.0 [4.0]	37.0 [49.6]

**Alternate emission standards are allowed for in-use compliance testing during this period

In 2000, U.S. EPA, ARB, and the South Coast Air Quality Management District co-sponsored catalyst durability testing for LSI engines at the Southwest Research Institute (SwRI). Test results showed that LSI engines are able to meet exhaust emission levels well below the current ARB standards using three-way catalysts and closed-loop fuel control, and that there is little to no degradation in the emission control system over the useful life of the engine.

Measure M12 in the 1994 SIP called for U.S. EPA to adopt an LSI engine program for preempt engines akin to California's current program. California cannot regulate a significant percentage of the emissions from LSI engines due to federal preemption. In 2002, utilizing the data generated from the SwRI test program, U.S. EPA finalized nationwide emission standards for these engines. The federal program aligns with California's exhaust emission standards for LSI engines with implementation beginning in 2004. In addition, U.S. EPA promulgated more stringent, Tier 2 requirements for LSI engines beginning in 2007. Starting with the 2007 model year engines, the federal Tier 2 exhaust emission standards for HC+NOx and CO are 2.7 g/kW-hr (2.0 g/bhp-hr) and 4.4 g/kW-hr (3.3 g/bhp-hr), respectively. Manufacturers must certify to these levels utilizing both a steady-state and transient test cycles. In addition, manufacturers may optionally certify engines according to a formula based on a HC+NOx/CO tradeoff. However, an engine cannot be certified to an HC+NOx standard above 2.0 g/bhp-hr or a CO standard above 15.4 g/bhp-hr. The emissions benefits from the federal standards are shown in Table II-D-4.

Table II-D-4
Lower Emission Standards for New Off-Road Preempt Engines
U.S. EPA 2002 Final Rulemaking
[Spark-Ignition Engines 25 hp and Greater]
Estimated Emission Reductions
(South Coast, Summer Planning, tpd)

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
ROG	0.2	0.2	0.3	0.4	0.6
NOx	0.9	0.9	1.4	1.7	2.7
PM10	0	0	0	0	0
CO	1.0	1.5	3.2	4.2	8.6

Note: These are emission reductions resulting from federal regulations. These emission reductions are not reflected in the baseline emissions shown in Table II-D-1.

3. Proposed Strategies

There are three additional emission reduction measures identified for this category of equipment that are summarized in Table II-D-5 below and further described in this section. These measures primarily affect ROG and NOx emissions.

Table II-D-5
Proposed Strategies for Off-Road Large Spark-Ignition Engines

Strategies	Timeframe	
	Action	Implementation
OFF-RD LSI-1: Set Lower Emission Standards for New Off-Road Gas Engines [Spark-Ignition Engines 25 hp and Greater]	2004 - 2005	2007
OFF-RD LSI-2 *(consolidated)*: Clean Up Off-Road Gas Equipment Fleet Through Retrofit Controls and New Emission Standards (Spark-Ignition Engines 25 hp and Greater)*	2004	2006 - 2012

*Consolidated OFF-RD LSI-2 and OFF-RD LSI-3 from May 2003 Proposed Strategy.

a. OFF-RD LSI-1: Set Lower Emission Standards for New Gas Engines (Off-Road Spark-Ignition Engines 25 hp and Greater)

Time Frame: Adopt 2004-2005; Implement 2007

Responsible Agency: ARB

Proposed Strategy:

***Background**:* To implement Measure M11 in the 1994 SIP, ARB adopted California's current HC+NOx and CO exhaust emission standards for the non-preempt portion of LSI engines and equipment. Staff relied on the expected exhaust emission reductions associated with closed-loop, three-way catalyst technology to develop the exhaust emission standards. Catalysts had long been used to reduce emissions from off-road spark-ignition equipment in special operating environments such as mines and indoor warehousing applications.

In 2002, U.S. EPA adopted more stringent emission standards based on catalyst durability testing co-sponsored by U.S. EPA, ARB, and the South Coast Air Quality Management District.

Additional Emission Reductions: ARB staff would propose the adoption of exhaust emission standards for new non-preempt engines, in alignment with the federal Tier 2 standards beginning with the 2007 model year. This would represent at least a 33 percent reduction from California's current HC+NOx exhaust emission standard.

Table II-D-6 summarizes the emission reductions expected from aligning with the federal emission standards. The benefits of OFF-RD LSI-2 are excluded from these reduction estimates.

Table II-D-6
OFF-RD LSI-1: Lower Emission Standards for New Off-Road Non-Preempt Gas Engines [Spark-Ignition Engines 25 hp and Greater]
Estimated Emission Reductions
(South Coast, Summer Planning, tpd)

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
ROG	0	0	0	0	0
NOx	0	0	0.3	0.8	1.6
PM10	0	0	0	0	0
CO	0	0	2.9	7.3	16.3

SIP Commitment for Measure OFF-RD LSI-1

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board between 2004 and 2005. The measure as proposed to the Board will, at a minimum, achieve 0.8 tpd of NOx reductions in the South Coast Air Basin in 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

b. OFF-RD LSI-2 *(consolidated)*: Clean Up Off-Road Gas Equipment Fleet Through Retrofit Controls and New Emission Standards [Spark-Ignition Engines 25 hp and Greater]*

Time Frame: Adopt 2004; Implement 2006-2012

Responsible Agency: ARB

Proposed Strategy:

This measure would reduce emissions from both existing and new LSI engine fleets, beyond the benefits of OFF-RD LSI-1. Staff will consider a multi-faceted approach that includes retrofit of existing engines and new emission standards at zero and near-zero levels.

The first approach to be evaluated is retrofit technology for existing engines. Recent data have shown that existing LSI engines retrofitted with catalyst-based emission systems could achieve emission reductions similar to those achieved from new engines designed with catalysts. Based on this data, it may be feasible to significantly reduce emissions from pre-2004 in-use LSI engines over 25 hp that have not been subject to new engine emission requirements. This includes some 2001 to 2003 models, and all pre-2001 models. The retrofit of existing equipment utilizing LSI engines could achieve an 80 percent reduction in exhaust emissions or meet emission levels equivalent to 3.0 g/bhp-hr HC+NOx. The retrofit technology would include a three-way catalyst and, on some engines, closed loop control of the fuel system.

The second approach to be evaluated would involve more stringent new engine emission standards, beyond the alignment with federal standards discussed in OFF-RD-LSI-1, to increase use of near-zero and zero-emission forklifts. Currently, the only commercially-available zero-emission forklifts are electric.

Electric forklifts are a technically feasible alternative to internal combustion engine forklifts in many applications, constituting about 25 percent of the total 8000 pound and under lift capacity counterbalanced forklift market (classes 1, 4, and 5) in the U.S. This percentage is significantly higher in some categories and weight classes. The Carl Moyer program has provided over $2 million in funding to incentivize the introduction of over 200 electric forklifts, demonstrating the potential of electric forklifts in applications where internal combustion engine forklifts had previously been used. The advent of more powerful and efficient motors and batteries, and fast-charging

* Consolidated OFF-RD LSI-2 and OFF-RD LSI-3 from May 2003 Proposed Strategy.

technology, should broaden the range of electric forklift applications and hasten the growth of the electric forklift market. However, electric forklifts will likely not be suitable for all applications due to operation requirements such as outdoor terrain challenges or high hours of use. In such cases, staff will evaluate the feasibility of near-zero emission standards instead

Forklifts with a lift capacity of 8,000 pounds or less in applications where charging infrastructure can be conveniently available will be the focus of the evaluation. Operational feasibility and economic impacts will be considered. Forklift owners may be able to recoup much of the incremental cost of some zero-emission forklifts due to their lower life cycle costs.

Projected benefits are based on implementation beginning in 2006 and phased in over six years. Tables II-D-7 and II-D-8 show the expected emission reductions for this consolidated measure in the South Coast and the San Joaquin Valley.

Table II-D-7
OFF-RD LSI-2 *(consolidated)*: Clean Up Off-Road Gas Equipment Fleet Through Retrofit Controls and New Emission Standards
[Spark-Ignition Engines 25 hp and Greater]
Estimated Emission Reductions
(South Coast, Summer Planning, tpd)

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
ROG	0	1.1	0.55-1.3	0.8-2.0	0.5-1.1
NOx	0.1	3.1	1-3	2-4	1-4
PM10	0	0	0	0	0-0.1
CO	0.4	2.1	4.4-8.8	10.8-21.6	27-55

Table II-D-8
OFF-RD LSI-2 *(consolidated)*: Clean Up Off-Road Gas Equipment Fleet Through Retrofit Controls and New Emission Standard
[Spark-Ignition Engines 25 hp and Greater]
Estimated Emission Reductions
(San Joaquin Valley, Winter Planning, tpd)

Pollutant	2010
ROG	0.2
NOx	0.3
PM10	--

SIP Commitment for Measure OFF-RD LSI-2

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board in 2004. The measure as proposed to the Board will, at a minimum, achieve between 0.8 and 2.0 tpd of ROG reductions and between 2 and 4 tpd of NOx reductions in the South Coast Air Basin in 2010.

San Joaquin 2003 PM10 SIP Commitment:

On June 26, 2003, the Board approved State commitments for the San Joaquin Valley's PM10 SIP. ARB staff commits to bring this measure to the Board in 2004. Emission reductions from this measure will be used toward meeting ARB's commitment to adopt new measures between 2002 and 2008 that reduce emissions by an additional 10 tpd NOx and 0.5 tpd direct PM10 in the San Joaquin Valley by 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

4. Long-Term Advanced Technologies Measures

Implementation of measure OFF-RD LSI-2, which includes retrofits, would be most effective if a tracking mechanism is established. For optimum effectiveness of the retrofit measure, ARB is considering enforcement of a statewide registration program analogous to the registration of a new vehicle purchase with the DMV. This program would enable authorities to track retrofitted off-road equipment by adopting a registration requirement in California in the same time frame as this retrofit strategy.

In addition, new technologies are always in the offing. Prototype cars, trucks, and buses powered by fuel cells are currently tested in the U.S. and Europe for performance and durability. Fuel cells are also being used in small vehicles and equipment, such as golf cars, neighborhood electric, airport ramp, forklifts, other material and people movers. In the future fuel cells may offer a zero emission, noiseless, odorless power source while retaining the vitality and functionality of conventional fuel-powered vehicles and equipment.

CHAPTER E

Small Off-Road Engines

CHAPTER E. SMALL OFF-ROAD ENGINES

1. Category Description

The small off-road engine (SORE or "small engine") category consists of off-road spark-ignition engines fueled typically by gasoline, liquid petroleum gas (LPG) or other alternative fuels and below 25 horsepower. The SORE category includes lawn, garden and other maintenance utility equipment. Within this category, engines are typically grouped by engine displacement measured in cubic centimeters (cc). Engines under 65 cc displacement are traditionally associated with handheld equipment such as weed trimmers, leaf blowers and chain saws. Engines greater than 65 cc displacement are collectively referred to as non-handheld small off-road engines. Non-handheld equipment is primarily lawn mowers, but also includes other equipment such as riding mowers and generator sets. U.S. EPA preempts new small engines used in farm and construction equipment from California emission regulation. The total South Coast small engine population is estimated to be over 6.5 million by 2010. Tables II-E-1 and II-E-2 summarize the handheld and nonhandheld emission inventory of small off-road engines in the South Coast for nonpreempt and preempt engines, respectively.

Table II-E-1
Baseline Emissions for Small Off-Road Engines (<25 hp)
(South Coast, Summer Planning, tpd) Nonpreempt

Pollutant	2005		2006 Annual Average		2008		2010		2020	
	Hand	Non	Hand	Non	Hand	Non	Hand	Non	Hand	Non
ROG										
exhaust	14.89	13.55	13.14	11.37	14.58	11.37	14.79	10.50	16.97	9.44
evap	2.17	16.17	2.10	16.16	2.25	16.77	2.31	17.14	2.61	19.14
NOx	0.46	4.01	0.43	3.77	0.49	4.48	0.51	4.74	0.58	5.62
PM10	0.14	0.18	0.09	0.16	0.07	0.18	0.07	0.19	0.08	0.21
CO	42.68	382.61	37.65	332.98	41.63	351.70	42.21	340.28	48.54	343.94

Table II-E-2
Baseline Emissions for Small Off-Road Engines (<25 hp)
(South Coast, Summer Planning, tpd) Preempt

Pollutant	2005		2006 Annual Average		2008		2010		2020	
	Hand	Non	Hand	Non	Hand	Non	Hand	Non	Hand	Non
ROG										
exhaust	7.74	5.06	5.94	4.08	5.36	3.77	5.00	3.49	5.58	3.46
evap	0.24	2.47	0.24	2.52	0.25	2.53	0.25	2.58	0.28	2.70
NOx	0.09	1.57	0.09	1.55	0.11	1.83	0.12	1.92	0.14	2.13
PM10	0.02	1.25	0.02	1.12	0.02	1.18	0.02	1.19	0.03	1.25
CO	23.78	132.08	19.59	114.56	18.20	116.59	15.68	114.03	16.92	118.30

Small engines have been subject to exhaust emission controls since 1995. Since then, emissions from this category have been cut by 30 to 70 percent.

Evaporative emissions are a significant source of hydrocarbons from this category as shown in the above tables. The sources of evaporative emissions from this category arise from gasoline vapors vented from the carburetor and fuel cap. These emissions arise from diurnal (emissions due to daily temperature changes), hot soak (occur after shutdown of equipment), and running loss (occur during equipment operation) processes. Permeation (liquid gasoline migrating through the walls of plastic fuel tanks) is also another source of emissions.

The emissions contribution from walk-behind mowers is a major portion of the total small engine category. The walk-behind mower population in 2010 is estimated to be over 60 percent of the total nonpreempt, nonhandheld engine population. The contribution of the nonhandheld engines to the emissions inventory is most evident during spring and summer months when vegetation growth rates and equipment activity are at their highest levels.

2. Existing Control Program

a. Emission Standards

ARB has adopted HC+NOx and CO emission standards for SORE, along with PM emission standards for 0-65 cc two-stroke engines. The standards differ by engine sizes. In 1990, the Board approved regulations for two tiers of engine emission standards for small off-road engine regulations and requested ARB staff to return with a status report twice before the 1999 implementation of the Tier 2 standards. The Tier 1 standards took effect in 1995 and required manufacturers to produce clean engine versions of their handheld and non-handheld equipment. In 1998, ARB modified the regulation to require small engines to demonstrate durability in their emission control systems. The Board also delayed the Tier 2 standards until January 2000 to provide sufficient time for manufacturers and distributors to comply with the revised regulations.

The Tier 2 standards encourage the use of advanced engine designs and emission controls. Handheld equipment engine standards are currently less stringent than non-handheld standards to maintain the use of two-stroke engine technology in applications where maneuverability is needed.

In July 1995, U.S. EPA finalized the first federal regulations affecting small engines. Phase 1 regulations took effect for most new handheld and non-handheld engines beginning in model year 1997 and were harmonized with the California Tier I standards that had been implemented two years earlier. The initial U.S. EPA and California engine standards resulted in a 32 percent reduction in HC emissions. U.S. EPA's Phase 2 small off-road engine standards were adopted separately for handheld equipment and non-handheld equipment. Standards were phased in beginning with the 2002 model year for handheld equipment and the 2001 model year for non-handheld equipment. U.S. EPA standards are less stringent than the California standards, except in one case. The federal HC+NOx emission standard for engines with less than 50 cc displacement beginning in 2005 is more stringent than the current ARB HC+NOx emission standard.

The 2000 and later California exhaust emission standards for small off-road engines are summarized in Table II-E-3.

Table II-E-3
California 2000 and Later Exhaust Emission Standards (Tier 2) for Small Off-Road Engines (Less Than 25 HP)

Calendar Year	Engine Displacement	Durability Periods (hours)	HC+NOx	CO	Particulate**
			grams per brake horsepower-hour [grams per kilowatt-hour]		
2000 and subsequent	0-65 cc, inclusive	50/125/300	54 [72]	400 [536]	1.5 [2.0]
2000 – 2001	>65 cc - <225 cc	N/A	12.0 [16.1]	350 [467]	N/A
	≥225 cc	N/A	10.0 [13.4]	350 [467]	N/A
2002 – 2005	>65 cc - <225 cc Horizontal	125/250/500	12.0 [16.1]	410 [549]	N/A
	>65 cc - <225 cc Vertical	N/A	12.0 [16.1]	350 [467]	N/A
2002 and subsequent	≥225 cc	125/250/500	9.0 [12.0]	410 [549]	N/A
2006 and subsequent	>65 cc - <225 cc	125/250/500	12.0 [16.1]	410 [549]	N/A

** The PM standard is applicable to all two-stroke engines.

3. Proposed Strategies

There are two emission reduction measures proposed for the small off-road engine sector listed in Table II-E-4. These measures affect ROG and NOx and are further described in the following section.

Table II-E-4
Proposed Strategies for Small Off-Road Engines

Strategies	Timeframe	
	Action	Implementation
SMALL OFF-RD-1: Set Lower Emission Standards for New Handheld Small Engines and Equipment [Spark-Ignition Engines Under 25 hp]	2003	2005
SMALL OFF-RD-2: Set Lower Emission Standards for New Nonhandheld Small Engines and Equipment [Spark-Ignition Engines Under 25 hp]	2003	2007

a. SMALL OFF-RD-1: Set Lower Emission Standards for New Handheld Small Engines and Equipment – Like Weed Trimmers, Leaf Blowers, and Chain Saws [Spark-Ignition Engines Under 25 hp]

Time Frame: Adopt 2003; Implement 2005

Responsible Agency: ARB

Proposed Strategy:

This measure will focus on reducing emissions from engines up to 65 cc displacement, and also extend the standards to include engines with displacements at or below 80 cc. These engines include handheld equipment such as weed trimmers and leaf blowers.

Staff proposes adoption in 2003 of a 50 g/kW-hr (37 g/bhp-hr) HC+NOx emission standard for less than 50 cc engines beginning in the 2005 model year to align with federal standards. The current HC+NOx emission standard of 72 g/kW-hr (54 g/bhp-hr) will remain the same for engines between 50 to 65 cc, and will also apply to engines up to and including 80 cc. (This standard is aligned with the most stringent federal standard.) In conjunction with the exhaust proposal, staff proposes the adoption of a 2.0 gram HC/m^2/day permeation performance standard, effective in the 2007 model year. The proposed standard will control permeation emissions from the fuel tanks on handheld equipment less than or equal to 80 cc.

Staff is also proposing the addition of an optional HC+NOx exhaust emission standard. Additional emission reductions from handheld engines could be obtained by the introduction of voluntary optional lower-emission standards and an environmental or "green" labeling program. The optional emission standard for HC+NOx would be 50 percent lower than the proposed 2005 standards. Engines certifying to optional standards would need to meet all other requirements that would otherwise be applicable to the model year engine, including warranty, useful life, and applicable testing. Incentive programs would be developed and utilized to promote the production of lower emission engines. This program is similar to U.S. EPA's "Blue Sky Series" engine program. Implementation of this program would benefit air quality by promoting the early development, introduction, and quicker widespread use of advanced low-emission technology.

Table II-E-5 lists the estimated emission benefits of this measure based on the draft inventory. The draft inventory is significantly higher than previous inventories for small off-road equipment, however it is still in the process of being finalized. The inventory (and the estimated emission benefits) may be modified when the Board considers this regulatory proposal at its September 2003 Board hearing.

Table II-E-5
SMALL OFF-RD-1: Set Lower Emission Standards for New Handheld Small Engines and Equipment [Spark-Ignition Engines Under 25 hp]
Estimated Emission Reductions
(South Coast, Summer Planning, tpd) Nonpreempt

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
ROG					
exhaust	0	0	1.1	1.5	1.9
evap	0	0	0.2	0.4	0.9
NOx	0	0	0.1	0.2	0.2
PM10	0	0	0	0	0
CO	0	0	0	0	0

SIP Commitment for Measure SMALL OFF-RD-1

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board in 2003. The measure as proposed to the Board will, at a minimum, achieve 1.9 tpd of ROG reductions and 0.2 tpd NOx reductions in the South Coast Air Basin in 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

b. SMALL OFF-RD-2: Set Lower Emission Standards for New Nonhandheld Small Engines and Equipment – Like Lawnmowers [Spark-Ignition Engines Under 25 hp]

Time Frame: Adopt 2003; Implement 2007

Responsible Agency: ARB

Proposed Strategy:

ARB staff proposes adoption in 2003 of a control measure that would require nonhandheld small off-road engine manufacturers to reduce combined HC+NOx emissions from new engines. This measure would begin with the 2007 model year and would require lower emission standards (25 percent to 50 percent lower than current levels) for engines with 80 cc – 225 cc displacement (Class I). For engines with greater than 225 cc displacement (Class II), the new emission standards would take effect in the 2008 model year. As with the existing emission standards, engines will be required to demonstrate durability and show that emission levels remain under the applicable standard. In addition, similar to the SMALL OFF-RD-1 measure, staff proposes to adopt optional HC+NOx exhaust emission standards that are 50 percent below the proposed standards. This measure could reduce the HC+NOx summer average emissions inventory attributed to these engines statewide by up to 40 percent in the 2020 calendar year.

In conjunction with the exhaust proposal, staff proposes the adoption of diurnal evaporative emission standards for Class I and Class II engines to substantially reduce evaporative emissions from gasoline powered off-road equipment. Staff proposes setting two diurnal evaporative emission standards for Class I engines, a 1.0 gram/day diurnal evaporative emission standard for walk-behind mowers and a sliding scale standards based on tank volume for all other Class I engines. Class I engine standards are effective in the 2007 model year. Staff proposes setting a 2.0 gram/day diurnal evaporative emission standard for Class II engines, effective in the 2008 model year. The measure is expected to reduce the HC summer average evaporative emissions attributed to these engines statewide by over 65 percent in the 2020 calendar year.

Table II-E-6 details the estimated exhaust emission reductions from the implementation of the above measure for Class I and Class II engines. Table E-II-6 also details the estimated ROG reductions based on the new evaporative and permeation standards. These estimates are based on the draft inventory. The draft inventory is significantly higher than previous inventories for small off-road equipment, however it is still being finalized. The inventory (and the estimated emission benefits) may be modified when the Board considers this regulatory proposal at its September 2003 Board hearing.

Table II-E-6
SMALL OFF-RD-2: Set Lower Emission Standards for New Nonhandheld Small Engines and Equipment
[Spark-Ignition Engines Under 25 hp]
Estimated Emission Reductions
(South Coast, Summer Planning, tpd) Nonpreempt

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
ROG					
exhaust	0	0	NQ	1.1-2.2	NQ
evap	0	0	NQ	5.2	NQ
NOx	0	0.1-0.2	NQ	0.6-1.9	NQ
PM10	0	0	0	0	0
CO	0	0	0	0	0

SIP Commitment for Measure SMALL OFF-RD-2

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board in 2003. The measure as proposed to the Board will, at a minimum, achieve between 6.3 and 7.4 tpd of ROG reductions and between 0.6 and 1.9 tpd of NOx reductions in the South Coast Air Basin in 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

CHAPTER F

Recreational Marine and Off-Road Vehicles

CHAPTER F. RECREATIONAL VEHICLES

1. Category Description

This category includes recreational marine engines as well as off-road motorcycles and all-terrain vehicles.

Recreational Marine:

The ARB's recreational marine engine program is an important element in the effort to improve air quality through reductions of hydrocarbon (HC) and oxides of nitrogen (NOx) emissions. Boat engines are divided into classes of outboards or inboards. Outboard engines are those which are mounted external to the boat structure. They typically hang on the rear wall of the boat. To minimize their weight, outboard engines have traditionally been two-stroke engines and thus for regulatory purposes are often grouped together with personal watercraft (PWC) engines, which are most commonly two-stroke jet-drives. Inboard and sterndrive engines are those which are situated within the confines of the boat hull. Inboard and sterndrive engines are generally automotive engines adapted for use in boats.

The recreational marine engine program does not include commercial marine engines, which are covered in Chapter G, Commercial Marine Vessels and Ports. Spark-ignition auxiliary marine engines (power generators, winches, or auxiliary propulsion engines for sailboats) are covered in Chapter E, Small Off-Road Engines (below 25 horsepower), or Chapter D, Off-Road Large Spark-Ignition Engines (25 horsepower and greater) depending on their size. Compression-ignition auxiliary and propulsion marine engines under 50 horsepower are covered in Chapter C, Off-Road Compression-Ignition (Diesel) Engines.

Tables II-F-1shows the emissions from recreational marine engines. These types of engines are a significant source of HC and NOx emissions and their contribution to the emissions inventory is most evident during the summer weekends when boating activity is at its highest levels.

Table II-F-1
Baseline Emissions for Recreational Marine Engines
(South Coast, Summer Planning, tpd)

	2010
ROG	35.7
NOx	15.9
PM10	5.4
CO	272.1

Off-Road Motorcycles and All-Terrain Vehicles:

This category consists of off-road motorcycles and all terrain vehicles (ATVs). Off-road motorcycles (dirt bikes) can be identified by their knobby tires and lack of lights and/or turn signals. They also have raised fenders to keep mud from gathering between the tire and fender. ATVs are nonroad vehicles having three or four wheels with knobby tires and a seat the operator straddles, much like an off-road motorcycle. Both are designed for operation over rough terrain. Off-road motorcycles and ATVs are used recreationally by thousands of Californians. Many recreation areas for these vehicles are located adjacent to or in urban areas suffering from poor air quality. Exhaust emissions are currently regulated but evaporative emissions are not. However, the U.S. EPA recently promulgated exhaust and evaporative standards for off-road motorcycles and ATVs to begin in 2006. Although the federal exhaust standards are not as stringent as California's, California will benefit from the evaporative standards which control fuel tank and fuel line permeability.

Table II-F-2
Baseline Emissions for Off-Road Motorcycles, All Terrain Vehicles, and Other Recreational Vehicles
(South Coast, Summer Planning, tpd)

Pollutant	2010
ROG	4.9
NOx	0.5
PM10	0.1
CO	69

2. Existing Control Program

a. Recreational Marine Engine Standards

The ARB adopted emission requirements for new outboard engines and personal watercraft in 1998 and exhaust emission standards for new inboard and sterndrive engines in 2001. These engines were previously uncontrolled.

In 1998, ARB adopted regulations requiring outboard and personal watercraft engine manufacturers to meet the 2006 U.S. EPA HC+NOx standards earlier (i.e., in 2001) and more stringent standards effective in 2004 and 2008. The ARB regulation differs from the federal rule primarily with respect to timing and stringency, while the rest of proposal is harmonized with the federal regulation wherever possible. This regulation also sets emission parts warranty requirements, consumer label requirements (which enable the purchaser to readily identify the new cleaner compliant models, and the inherently lower-emitting four-stroke models), and production line and in-use testing requirements. The U.S. EPA standards for outboard engines, which phase in between 1998 and 2006, ultimately require a 75 percent HC reduction for new engines.
Table II-F-3 below compares the federal and California phased-in exhaust emission standards for a 75-kilowatt (100 horsepower) outboard marine engine, the size of the typical personal watercraft engine.

Table II-F-3
New Outboard Engine Emission Standards
(75 kilowatt engine)

	Federal	**California**
Year	**HC+NOx** g/kW-hr*	**HC+NOx** g/kW-hr*
1998	151	-
1999	138	-
2000	125	-
2001	113	47
2002	99	47
2003	86	47
2004	72	36
2005	60	36
2006	47	36
2007	47	36
2008	47	16

*grams per kilowatt-hour

With the exception of positive crankcase ventilation (PCV), inboard and sterndrive engines do not employ emission control systems or devices. Many new inboard and sterndrive engines still use carburetors to meter fuel delivery. Other engines with electronic fuel injection are typically calibrated without regard for emissions and produce more NOx than identical engines with carburetors. In July 2001, ARB adopted regulations requiring inboard and sterndrive engine manufacturers to cap combined HC+NOx emissions at 16 grams per kilowatt hour (g/kW-hr), and later to reduce combined HC+NOx emissions from new engines to 5 g/kW-hr for at least 480 hours of use. The cap is effective beginning in 2003. Beginning in 2007, manufacturers are required to comply with the 5 g/kW-hr requirement on 45 percent of product sales, but the number of complying engines ramps to 75 percent in 2008 and 100 percent in 2009 and later. The combined HC+NOx emissions inventory attributed to inboard and sterndrive engines is expected to be reduced by approximately 31 percent statewide by the 2020 calendar year. Furthermore, beginning in 2007, new engines complying with the 5 g/kW-hr HC+NOx standard will be required to possess an integrated on-board diagnostics system to rapidly identify and aid in the correction of emission related malfunctions.

It is expected that compliance with the 5 g/kW-hr standard will be achieved through the incorporation of catalytic converters in 2007/8/9. Catalytic converters have been used successfully for many years on on-road gasoline engines and are routinely capable of reducing HC and NOx from those engines in excess of 90 percent. Technology demonstrations have shown the feasibility of equipping existing marine engines with catalytic converters and feedback control systems to reduce emissions to suitable levels. A majority of the marine engines that are affected by this emission standard share compatibility with on-road electronic control modules that already possess acceptable on-board diagnostics II software. ARB anticipates that some re-calibration will be necessary to successfully transfer diagnostic technology from on-road applications to marine applications.

b. Off-Road Motorcycle and All-Terrain Vehicle Emission Standards

In 1994, the ARB approved off-highway recreational vehicle regulations (including off-road motorcycles). These regulations established exhaust emission standards and test procedures that included off-road motorcycles and ATVs. The regulations also provided specific coding requirements of the vehicle identification number to distinguish an emission-compliant vehicle. In 1998, the regulations were amended to link vehicle registration and usage to compliance with California's exhaust emission standards. Those in compliance are eligible for off-highway vehicle (OHV) green sticker registration that allows year-round operation in designated off-road areas. Those not in compliance are eligible for OHV red sticker registration that allows operation only during designated months when ozone levels are low. These revisions affect engines built in 1997 greater than 90 cc. The same standards also apply to engines built in 1999 of 90 cc or less. Engines built pre-1997 and pre-1999, respectively, are not subject to this regulation.

Because the recently adopted emission standards for new recreational vehicle engines are still being phased in through 2009, new measures calling for stricter emission standards would not provide emission benefits by 2010. However, concepts to reduce emissions from in-use recreational vehicle engines may be promising in the long-term.

CHAPTER G

Commercial Marine Vessels and Ports

CHAPTER G. COMMERCIAL MARINE VESSELS AND PORTS

1. Category Description

Commercial marine vessels and land-based maritime or port-related activities are addressed in this chapter. Brief descriptions of these categories and their emissions are provided below.

a. Commercial Marine Vessels

Commercial marine vessels include ocean-going ships and harbor craft, but excludes recreational vessels. Ocean-going ships include international trade vessels such as container ships, bulk carriers, general cargo ships, tankers, and auto carriers. Passenger cruise ships, and some military and Coast Guard vessels, are also included in this category.

Most ocean-going vessels are propelled by large diesel piston engines (motor ships), although some are powered by steam turbines (steam ships), or diesel-fueled gas turbines. In addition, diesel piston or turbine engines may be used to drive generators to produce electricity for an electric propulsion motor (i.e., diesel-electric). The diesel-electric configuration is commonly used in passenger cruise ships.

The diesel piston engines powering the majority of oceangoing ships are referred to by U.S. EPA as “Category 3” engines, meaning they have a displacement greater than 30 liters per cylinder. These engines are available in configurations with 4 to 14 cylinders, and power outputs ranging from roughly 5 to 100 megawatts. The larger diesel engines produce more power than many land-based electric generating power plants, and in some cases similar engines have been used as power plants.

In addition to the propulsion engines, ocean-going ships generally run diesel generators and boilers, particularly while “hotelling” in port. Diesel generators provide electrical power for lights and equipment, and boilers provide steam for hot water and fuel heating. Hotelling emissions are a significant component of marine vessel emissions in the South Coast Air Basin (SCAB). For example, in 2000 they are responsible for nearly 30 percent of the nitrogen oxide emissions from commercial marine vessels within the district.

Although the power systems described above are described as “diesel-fueled,” the types of fuel vary. Most ocean-going ships run their main propulsion engines (and many newer ships also run their auxiliary engines) on intermediate fuel oil (IFO 180 or IFO 380). This fuel is also referred to as “bunker fuel,” and requires heating to reduce its viscosity to a point where it can be properly atomized and combusted. Bunker fuel typically contains much higher levels of sulfur, nitrogen, ash, and other compounds which increase exhaust emissions. For example, typical bunker fuel used by ships visiting the Ports of Los Angeles and Long Beach averages about 2.8 percent sulfur (28,000 ppm), compared to about 120 ppm sulfur for California on-road diesel. Diesel-powered gas turbine engines and auxiliary engines on many ocean-going ships use lighter "distillate" diesel fuel (also referred to as marine gas oil), which is much lower in sulfur and other contaminants.

Harbor craft (or the "captive fleet") include tugboats, commercial fishing vessels, commercial passenger fishing vessels ("party boats"), work boats, crew boats, ferries, and some Coast Guard and military vessels. These vessels generally stay within California coastal waters and often leave and return to the same port. Most harbor craft use diesel-powered propulsion and auxiliary engines. Harbor craft propulsion and auxiliary engines in California generally run on distillate diesel fuel, such as U.S. EPA on-road diesel.

The baseline and projected emissions of reactive organic gases (ROG), nitrogen oxides (NOx), particulate matter (PM), sulfur oxides (SOx), and carbon monoxide (CO) from marine vessels are shown in Table II-G-1. The emissions inventories are shown for the South Coast Air Basin (SCAB) in both summer planning and annual average format. As noted in the footnote to the tables, the inventory figures include the effect of the International Maritime Organization's (IMO) regulation of nitrogen oxides, but not the impact of U.S. EPA's harbor craft regulation, and local California programs such as the Carl Moyer program. ARB staff is currently working to develop an improved statewide emissions inventory for marine vessels that will include the effect of national and California-specific programs.

As shown in Table II-G-1, marine vessels are a significant source of emissions in the SCAB. For perspective, marine vessels currently contribute about 12 percent of the SCAB's particulate matter, and about 4 percent of the NOx emissions. In addition, the port facilities where these marine vessel emissions are concentrated are often located near population centers, which may be exposed to elevated levels of toxic diesel PM. In the SCAB, this is of particular concern for the communities surrounding the Los Angeles/Long Beach Port Complex.

Table II-G-1
Baseline Emissions for Marine Vessels
(South Coast Air Basin, Summer Planning, tpd)

Pollutant by Vessel Type	2000	2005	2006 (Annual Average)	2008	2010	2020
ROG						
Ocean-going ships	3.5	3.9	4.0	4.2	4.3	5.8
Harbor craft	0.4	0.4	0.4	0.4	0.4	0.4
Total	3.9	4.3	4.4	4.6	4.7	6.2
NOx						
Ocean-going ships	35.4	41.2	42.4	44.7	47.1	67.5
Harbor craft	10.5	10.6	10.7	10.7	10.7	11.4
Total	45.9	51.8	53.1	55.4	57.8	78.9
PM10						
Ocean-going ships	3.0	3.4	3.4	3.6	3.7	5.1
Harbor craft	0.2	0.2	0.2	0.2	0.2	0.2
Total	3.2	3.6	3.6	3.8	3.9	5.3
SOx						
Ocean-going ships	25.8	29.7	30.5	32.0	33.5	48.1
Harbor craft	0.2	0.2	0.2	0.2	0.2	0.2
Total	26.0	29.9	30.7	32.2	33.7	48.3
CO						
Ocean-going ships	4.1	4.8	4.9	5.1	5.4	7.8
Harbor craft	1.4	1.4	1.4	1.5	1.5	1.6
Total	5.5	6.2	6.3	6.6	6.9	9.4

Source: 2000 ARB Emissions Inventory. These emission inventory figures include the effect of the IMO regulation of nitrogen oxides, but do not reflect emission reductions expected from U.S. EPA's harbor craft regulation, or the California-based programs summarized in this chapter.

b. Land-Based Port Activities

California's ports support a tremendous amount of commerce, as well as tourism and military operations. California's coastline and inland waterways support a number of ports, including the Ports of Hueneme, Long Beach, Los Angeles, Oakland, Redwood City, Richmond, Sacramento, San Diego, San Francisco, and Stockton. The ports of Los Angeles and Long Beach in the SCAB are among the largest in the country, and the combined Los Angeles/Long Beach Port complex is one of the world's largest ports.

Ports in California are established by State government, and are operated by entities such as port authorities and departments of municipal governments. For example, the Port of Los Angeles is an independent department of the City of Los Angeles and is under the control of a five-member Board of Harbor Commissioners appointed by the Mayor and approved by the City Council.

A primary focus of California's larger ports, including the Ports of Los Angeles and Long Beach, is the inter-modal transfer of "containerized" cargo between ships, and railroads and heavy-duty trucks. Other ports mainly support the commercial fishing industry or military operations. It is also common to find a variety of different commercial enterprises operating on port land, such as airports, power plants, refineries, office complexes, retail development, and recycling operations. Ports may either directly operate terminals and other port facilities, or lease property to other entities.

A number of land-based port activities contribute to port emissions. Among these sources, the emissions from on-road heavy-duty diesel trucks are probably of greatest concern. Trucks enter and leave the ports to pick up or deliver containerized cargo. During these trips, trucks often form bottlenecks at key checkpoints, where they can idle for long periods as they slowly move forward. In addition, the trucks that service the ports tend to be disproportionately older vehicles with higher emissions.

Other major sources of emissions at the ports include diesel-powered locomotives and port-handling equipment. Locomotives, like heavy-duty trucks, transport cargo containers, while cargo-handling equipment is used to move containers around at the port terminals. Cargo-handling equipment includes yard trucks, rubber-tired gantry cranes, top-picks, side-picks, and forklifts.

Other emissions sources at the ports include light- and medium-duty vehicles, recreational marine vessels, diesel-powered transport refrigeration units, emergency/standby generators, petroleum handling and storage, maintenance and repair operations, and the variety of commercial enterprises located on port property. Descriptions of many of these sources, including heavy-duty diesel trucks, locomotives, and off-road diesel engines (which includes cargo-handling equipment), have been provided in other chapters in this document.

Currently, ARB does not have port-specific emission inventories that take into account all of the emissions that are attributable to port activities. However, the emissions from these activities are included in the regional emissions inventories for both on-road and off-road vehicles and in the stationary point source inventory. As mentioned later in this chapter, ARB staff plans to develop port-specific emission inventories to help ascertain the need for additional emission reductions to reduce the impacts on neighborhoods located near port operations.

2. Existing Control Programs for Commercial Marine Vessels

In contrast to other mobile sources, marine vessels are relatively recent newcomers to the air quality regulatory arena. However, within the last several years, action has been taken at both the international and national level to regulate emissions from commercial marine vessels. As explained below, these regulations are expected to achieve relatively modest emission reductions in California. Other programs established within California will result in reduced emissions. These, along with the national and international regulations, are described below.

a. International Maritime Organization Regulation

The International Maritime Organization established NOx standards in Annex VI to the International Convention for the Prevention of Pollution from Ships in 1997. The standards apply to diesel engines over 130 kW (174 hp) installed on new vessels. Standards for PM and hydrocarbons (HC) were not included in the regulation. As shown in Table II-G-2 below, the NOx standards range from 9.8 to 17 g/kW-hr, depending on the rated engine speed.

Table II-G-2
IMO NOx Standards

Engine Speed (rpm)	NOx (g/kW-hr)
$n < 130$	17.0
$130 \leq n < 2000$	$45n^{(-0.2)}$
$n \geq 2000$	9.8

Unfortunately, the IMO standards do not become enforceable until ratified by 15 countries that represent at least 50 percent of the gross tonnage of the world's merchant shipping. To date, this has not happened, and the United States is among the countries that have not ratified these standards. However, the standards are retroactive to January 1, 2000, if ratified, and engine manufacturers have generally produced IMO compliant engines since that date. The NOx emission reductions in California resulting from the IMO regulation are estimated to be modest. For example, the emission reductions resulting from the IMO regulation in the SCAB are estimated to be about 1.7 tons of NOx per day in 2010 for ocean-going ships (Arcadis, 1999).

b. U.S. EPA Standards

U.S. EPA promulgated final exhaust emission standards for new diesel engines over 37 kW (50 hp) on December 29, 1999 (64 FR 73301). The standards apply primarily to commercial harbor craft because the rule exempts recreational craft and the large “Category 3” engines (over 30 liters per cylinder) used by ocean-going vessels. The standards apply to combined NOx+ROG, PM, and CO. As shown in Table II-G-3 below, the specific standard and implementation date depends on the engine cylinder displacement. The NOx+ROG standards range from 7.2 to 11 g/kW-hr, the particulate matter standards range from 0.20 to 0.50 g/kW-hr, and the carbon monoxide standard is 5.0 g/kW-hr. The implementation dates range from 2004 to 2007, depending on engine size. The emission reductions from the federal rule are expected to be modest. The NOx standards will not achieve significant emission reductions until after 2010, since the standards only apply to new engines introduced beginning 2004-2007. In addition, the PM and CO standards are effectively caps in many cases, designed primarily to prevent increases.

Table II-G-3
U.S. EPA “Tier II” Marine Diesel Emission Standards

Engine Category	Displacement (liter/cyl)	Starting Date	NOx+THC (g/kW-hr)	PM (g/kW-hr)	CO (g/kW-hr)
1	D < 0.9	2005	7.5	0.40	5.0
	0.9 ≤ D < 1.2	2004	7.2	0.30	5.0
	1.2 ≤ D < 2.5	2004	7.2	0.20	5.0
	2.5 ≤ D < 5.0	2007	7.2	0.20	5.0
2	5 ≤ D < 15	2007	7.8	0.27	5.0
	15 ≤ D < 20 (P < 3300 kW)	2007	8.7	0.50	5.0
	15 ≤ D < 20 (P ≥ 3300 kW)	2007	9.8	0.50	5.0
	20 ≤ D < 25	2007	9.8	0.50	5.0
	25 ≤ D < 30	2007	11.0	0.50	5.0

With regard to ocean-going ships, U.S. EPA promulgated final exhaust emission standards for new diesel engines at or above 30 liters per cylinder (“Category 3” engines) on February 28, 2003 (68 FR 9745). The rule was developed as part of a settlement agreement with the Bluewater Network, an environmental advocacy group. Under the rule, new Category 3 engines built in 2004 or later on U.S.-flagged vessels would be subject to the IMO NOx standards established in 1997. The U.S. EPA also committed to developing a second tier of standards for Category 3 engines in 2007, and to considering the application of these standards to engines on foreign vessels that enter U.S. ports. In addition, the rule imposes the 1997 IMO NOx standards on new engines with a displacement at or above 2.5 liters per cylinder, but less than 30 liters per cylinder. The IMO NOx standards for these engines would expire in 2007, when the more stringent U.S. EPA Tier 2 standards adopted in 1999 (64 FR 73300) become effective. Unfortunately, the U.S. EPA’s Category 3 engine rule will not achieve significant emission reductions because manufacturers are already making IMO compliant engines. In addition, the vast majority of ocean-going ships calling on California's ports are foreign-flagged vessels.

c. South Coast District Credit Generation Rules

On May 11, 2001, the South Coast District adopted four rules designed to generate NOx emission reduction credits for its Regional Clean Air Incentives Market (RECLAIM) program. Two of these rules (Rules 1631 and 1632) apply to marine vessels. Rule 1631, Pilot Credit Generation Program for Marine Vessels, allows the generation of NOx credits through the voluntary replacement of diesel engines in harbor craft with new, cleaner engines. Several vessel owners have entered into the program to date, and the Rule was recently amended to also allow for the inclusion of remanufactured, as well as new engines.

Under Rule 1632, Pilot Credit Generation Program for Hotelling Operations, NOx credits can be generated when vessels near ports use electrical power supplied by fuel cells (normally, hotelling power is generated from onboard diesel generators). The Rule envisions that fuel cells would be located on a mobile barge that could move to individual vessels. To date, credits have not been generated under Rule 1632.

Minimal emission reductions will be generated from Rules 1631 and 1632 because any emission reductions achieved by these programs will be used to generate credits, allowing inland sources such as power plants to increase their emissions (less a 10 percent "discount" retired for the benefit of the environment).

d. Carl Moyer Program

The Carl Moyer Program is a heavy-duty diesel engine incentive program designed to obtain early emission reductions of NOx and particulate matter from heavy-duty vehicles and equipment, including marine vessels. Under the program, ARB has the responsibility to establish program guidelines, oversee the program, and report program benefits. Local air districts implement the program and work with the public and private participants. The program provides grants to pay for the extra cost of replacing existing diesel engines with lower-emission engines, including new cleaner diesels, or engines powered by alternative fuels or electricity. The marine vessel projects funded under the Carl Moyer Program are primarily repower projects where older diesel engines are replaced with cleaner diesel engines on fishing vessels and tugboats.

From 1998-2000, marine vessel projects constituted about five percent of the overall emission reductions from the Carl Moyer Program. Specifically, during the 1998-1999 fiscal year, the Carl Moyer Program funded marine vessel projects that resulted in NOx emission reductions of 357 tons per year (tpy), and will continue to generate emission reductions over the estimated 20-year life of the projects. During the 1999-2000 fiscal year, additional marine vessel projects generated an additional 29 tpy NOx emission reductions.

3. Existing Control Programs for Port Dockside Activities

The land-side sources of emissions at the ports are virtually all subject to regulations at the federal, State, or local level. A brief summary of the existing control programs for some of the larger emissions sources is provided below. More detailed descriptions of most of these programs are found in other chapters in this document, as cited below. In addition, many ports have implemented additional emission reduction programs of their own, partly to mitigate emission increases due to port expansions. For example, ports have worked with their customers to introduce cleaner-burning fuels and add-on controls on cargo handling equipment and on-road trucks. Some ports have also provided opportunities to utilize electrical power as an alternative to diesel engines, where feasible.

a. On-Road Vehicles

ARB has regulated on-road vehicles since the 1960s, and continues to require progressively cleaner engines in new vehicles. ARB's standards for light- and medium-duty vehicles and standards for heavy-duty gasoline and diesel engines are described in Chapters A and B of this Section.

b. Off-Road Equipment

Diesel-powered cargo handling equipment at the ports is generally subject to both U.S. EPA and ARB off-road compression-ignition (diesel) standards. Under a 1996 agreement, these regulations are harmonized to prevent two sets of standards. The U.S. EPA/ARB off-road equipment standards apply to new engines, and the emission standards vary with the size of the engine. A special situation applies to new engines used in construction and farming equipment less than 175 horsepower. California is preempted by federal law from regulating these engines, and they are only subject to U.S. EPA standards. However, most port handling equipment is above 175 horsepower. Chapter C describes the programs for off-road diesel equipment in more detail.

c. Locomotives

Like marine vessels, locomotives are relatively new to air quality regulatory requirements. The existing programs for locomotives are described in detail in Chapter I of this document.

d. Stationary Sources

The local air pollution control agencies have the primary authority to regulate emissions from stationary sources. A variety of stationary sources are found on port property, including power plants, refineries, diesel generators, boilers, repair and maintenance facilities, and fuel storage and handling equipment. These sources are subject to local regulation, standards, permits, and new source review requirements.

4. Proposed Strategies

ARB is proposing the two measures listed in Table II-G-4 for the "commercial marine vessels and ports" component of the South Coast SIP. One of these measures controls emissions from marine vessels, while the other applies to land-side port sources.

The proposed measures include different regulatory options that would be pursued or evaluated for implementation. The measures provide flexibility, in part, due to the many uncertainties and challenges that are expected in developing programs for marine vessels. The marine industry is complex and has only recently been subject to air quality regulation. Information regarding duty cycles, emission factors, and the effectiveness of controls on marine engines is less definitive than for other mobile sources that have been subject to air quality regulations for many years. In addition, the proposed measures will require the cooperation and collaboration of multiple agencies on the local, State, national, and international level.

To provide a central point in California for the coordination and discussion of air quality strategies for the maritime community, ARB established the Maritime Air Quality Technical Working Group (Maritime Working Group). The Maritime Working Group is open to all interested parties and includes representatives from a variety of stakeholders, including the ports, commercial shipping companies, U.S. EPA, the local districts, maritime industry associations, and community and environmental groups. A key task of the Maritime Working Group will be to participate in the development of emission reduction strategies for commercial marine vessels and dockside equipment. The measures described below will impact maritime activities, and ARB envisions the Maritime Working Group providing critical input to the development of those measures. However, the Maritime Working Group is not intended to replace the public process necessary for development of regulatory proposals. The Maritime Working Group will instead enhance that process and provide a place where frank and open discussions can be conducted on maritime air quality impacts and emission reduction strategies.

Table II-G-4
Proposed Strategies for Commercial Marine Vessels and Ports

Strategies	Timeframe	
	Action	Implementation
MARINE-1: Pursue Approaches to Clean Up the Existing Harbor Craft Fleet - Cleaner Engines and Fuels	2003 – 2005	2005
MARINE-2: Pursue Approaches to Reduce Land-Based Port Emissions - Alternative Fuels, Cleaner Engines, Retrofit Controls, Electrification, Education Programs, Operational Controls	2003 – 2005	2003 - 2010

a. MARINE-1: Pursue Approaches to Clean Up the Existing Harbor Craft Fleet – Cleaner Engines and Fuels

Time Frame: Adopt 2003-2005; Implement 2005

Responsible Agency: ARB

Proposed Strategy:

Under this measure, ARB is proposing to reduce NOx, ROG, and PM emissions from existing "in-use" harbor craft engines. The proposed measure includes a number of options, including: (1) the use of add-on control equipment; (2) repowering of existing vessels or early introduction of new vessels; and (3) cleaner fuels such as California on-road low sulfur diesel, emulsified diesel fuels, biodiesel, compressed natural gas (CNG), or liquefied natural gas (LNG). Due to the diversity within the harbor craft category, specific emission reduction proposals may vary with the type of vessels, industry, or other factors. Several strategies would be evaluated to determine the most effective means to reduce emissions from in-use engines. These are described below.

Add-On Control Equipment: Dramatic reductions in both NOx and PM emissions can be achieved with exhaust treatment devices. ARB's Diesel Risk Reduction Plan (RRP) anticipates PM emission reductions from harbor craft. The reductions in the RRP are expected to result from the use of diesel particulate filters (DPFs). DPFs trap and oxidize PM using the heat of the engine's exhaust, along with a catalyst (passive systems) or supplemental heat source (active systems). DPFs are currently used in a variety of on-road and off-road mobile source applications. While their use in marine engines is currently limited, ARB believes that they can be used in many marine applications. To evaluate the effectiveness of installing traps on marine engines, ARB is providing funding to the U.S. Navy to include an evaluation of DPFs in a study they are initiating to evaluate different in-use emissions control technologies on marine military craft. DPFs can achieve PM emission reductions of 90 percent or more, along with similar reductions in HC and CO. DPFs require the use of low sulfur fuel and, in the case of passive systems, engine duty cycles that generate exhaust temperatures high enough to effectively oxidize trapped PM.

Another option for PM control is diesel oxidation catalysts (DOCs). DOCs reduce the soluble organic fraction of diesel PM, which includes many of diesel PM's toxic components. DOCs typically result in overall PM control efficiencies of about 25 percent, along with significant reductions in HC and CO.

NOx emissions can be controlled from existing engines by the use of selective catalytic reduction (SCR). SCR is currently used in over 50 marine vessels of various types, primarily in Europe. SCR reduces NOx to nitrogen and water through the use of a catalyst and a reducing agent (e.g., urea solution). SCR can be used in many marine applications to achieve NOx emission reductions of 65-90 percent.

Other NOx exhaust treatment control options include lean-NOx catalysts and rapidly developing technologies such as NOx adsorbers and plasma-catalyst systems. In addition, while not exhaust treatment devices, controls such as water injection, injection timing retard, exhaust gas recirculation, and humid air motor (HAM) technology can achieve significant NOx reductions from existing engines. NOx reductions can also be achieved by more significant mechanical changes to the engine, particularly during rebuilding.

In addition, there is an emerging trend in the development of add-on control systems that can control both PM and NOx. For example, combination systems incorporating both DPFs and SCR, or DPFs and NOx adsorbers. Another option to control both NOx and PM is the combination of add-on controls with cleaner fuel options (as described below). Examples of this strategy include the use of emulsified fuels and oxidation catalysts, and biodiesel in combination with NOx control strategies.

Cleaner New Engines: Replacement of older engines is another option to reduce emissions from the existing fleet. We will investigate additional programs to encourage replacement of older engines with cleaner new models. In addition, we will investigate incentives to accelerate the introduction of new cleaner vessels in the district, which will be subject to U.S. EPA's harbor craft standards beginning 2004 to 2007.

Cleaner Burning Fuels: Harbor craft can use off-road diesel fuel with much higher sulfur and aromatics levels compared to California on-road lower sulfur fuel. In practice, harbor craft use federal off-road diesel, federal on-road diesel, and California on-road diesel. The extent to which each of these fuels are used is not known. However, ARB estimates that the industry is primarily using the federal off-road and federal on-road diesel. Both of these fuels have higher levels of aromatics compared to California on-road diesel and result in higher NOx and PM emissions. Sulfur oxides (SOx) emissions are a function of the sulfur content of the fuel, and federal off-road fuel may be as high as 5,000 ppm sulfur, compared to the 500 ppm requirement for federal on-road and California on-road diesel.

The easiest cleaner fuel option may be to switch to California on-road diesel fuel (with 15 ppm sulfur) which will be available in mid-2006. Under AB 2135 (passed into law in August 2000), diesel ferries with a capacity to hold 75 or more passengers are required to use California on-road diesel fuel as of January 1, 2003. Some ferry operations are already beginning to use California on-road diesel. The use of California on-road diesel will result in reductions in NOx, SOx, and PM, compared to federal on-road and off-road diesel. Specifically, reductions in PM and NOx compared to federal on-road diesel would be about 25 percent and 7 percent, respectively. Reductions compared to off-road diesel would be even higher and would result in significant SOx reductions. In addition, the California 15 ppm sulfur diesel fuel has the advantage of enabling more efficient use of exhaust treatment devices such as DPFs.

More significant reductions in PM and NOx could be achieved with the use of water/diesel emulsions. Test data for one product (PuriNox) demonstrate NOx reductions of up to 14 percent and PM reductions of up to 63 percent, compared to standard California on-road diesel, depending on the engine and application.

Biodiesel is another option. Biodiesel is derived from vegetable oils or recycled restaurant grease, and can be mixed with diesel fuel or used straight. Pure biodiesel can reduce PM emissions by over 50 percent. However, it generally also results in an increase in NOx emissions. For this reason, it is best used along with NOx control strategies. Biodiesel manufacturers are also working on additives that can be used to prevent the increase in NOx emissions.

Use of compressed or liquefied natural gas or diesel/CNG dual fuel applications can result in significant reductions in NOx and particulate emissions. The resulting emission reductions vary widely with the specific application and the ratio of diesel to CNG for dual fuel applications. In addition, the use of these fuels will require more extensive vessel and engine modifications compared to other clean fuel options.

Table II-G-5 summarizes the estimated emission reductions from this measure, based on a 25 percent reduction in NOx, PM, and ROG phased in over three years, beginning in 2006. The reductions also reflect the anticipated implementation of federal emission controls, as described in the long-term advanced technology section of this chapter. The emission reduction strategies necessary to achieve these reductions will vary with the vessel type or industry affected, and any emission reduction program would likely not require the use of any given technology, leaving it up to the vessel owner to chose the technology that best fits the particular vessel.

Table II-G-5
MARINE-1: Pursue Approaches to Clean Up the Existing Harbor Craft Fleet – Cleaner Engines and Fuels
Estimated Emission Reductions in the South Coast Air Basin
(Summer Planning, tpd)

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
ROG	Not Applicable	0.03	0.1	0.1	0.05
NOx	Not Applicable	0.09	2.7	2.7	2.2
PM10	Not Applicable	0.02	0.05	0.05	0.02

SIP Commitment for Measure MARINE-1

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board between 2003 and 2005. The measure as proposed to the Board will, at a minimum, achieve 0.1 tpd of ROG reductions and 2.7 tpd of NOx reductions in the South Coast Air Basin in 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

b. MARINE-2: Pursue Approaches to Reduce Land-Based Port Emissions–Alternative Fuels, Cleaner Engines, Retrofit Controls, Electrification, Education Programs, Operational Controls

Time Frame: Adopt 2003-2005; Implement 2003-2010

Responsible Agency: ARB

Proposed Strategy:

As mentioned previously, a number of land-based on- and off-road sources contribute to port emissions. These sources include: (1) stationary sources such as refineries and repair and maintenance facilities; (2) portable equipment such as dredges; (3) off-road mobile sources such as cargo handling equipment and locomotives; and (4) on-road mobile sources such as heavy-duty trucks.

On-road heavy-duty trucks are a particular concern due to the heavy volume visiting California's larger commercial ports, such as the Ports of Los Angeles and Long Beach. It is not unusual to have numerous trucks idling simultaneously as they wait for their cargo to be loaded or unloaded. The trucks then inch forward at very slow speeds as the line moves. The diesel exhaust emissions from these trucks pose a serious air quality and health threat, particularly to those individuals that work at the port or live in nearby residences.

While the emissions from land-side port sources are included in the regional emission inventories, port-specific inventories are not currently available. This makes it difficult to assess the impacts of control programs on port emissions and the communities surrounding the ports.

ARB staff is proposing a broad-based measure focusing specifically on California's ports because of the heavy concentration of emission sources at the ports, the dramatic growth in trade expected at some ports, and their proximity to residential areas. In addition, ports have a unique ability to assist in environmental programs within their jurisdiction, and many have been actively involved in evaluating and implementing emission reduction strategies to reduce their emissions.

This measure outlines a three-step process for addressing port land-side emissions. First, port-specific inventories would be created for California ports. ARB would work closely with the ports, the local districts, the regional transportation agencies and U.S. EPA to develop an inventory model that would encompass the broad range of emissions that occur in the ports. This work has already begun for the Ports of Los Angeles and Long Beach, and results are expected in 2003. Second, once the inventories are prepared, ARB staff would assess the impacts of existing and planned control measures on port emissions, and determine the additional port-specific emission reduction strategies needed to help attain regional air quality goals and to protect the health of communities near the ports. Strategies to be evaluated may include early introduction of cleaner new vehicles and equipment, expanded use of alternative fuels, repowering with cleaner new engines, add-on control equipment, electrification of diesel equipment, public education programs, and operational changes such as idling limits.

The implementation timeline for this measure is outlined in Table II-G-6.

Table II-G-6
MARINE-2: Pursue Approaches to Reduce Land-Based Emissions at Ports
Specific Strategies

Strategies	Timeframe	
	Action	Implementation
Create port-specific emission inventories	2003	2003
Assess impacts of existing and planned measures to determine additional emission reductions that are necessary	2003 – 2005	2003 – 2005
Identify and implement port-specific measures	2003 – 2005	2005 – 2010

The emission reductions from this measure are difficult to estimate since port-specific emissions inventories are not yet available. For this reason, we are simply estimating that proposals developed under this measure will achieve a small but measurable (0.1 tpd) reduction in NOx, PM, and ROG emissions beyond existing and proposed SIP measures beginning in 2005. It is expected that further reductions will be achieved as the proposals in this measure are more fully developed over time.

SIP Commitment for Measure MARINE-2

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board between 2003 and 2005. The measure as proposed to the Board will, at a minimum, achieve 0.1 tpd of ROG reductions and 0.1 tpd of NOx reductions in the South Coast Air Basin in 2010.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

5. Long-Term Advanced Technologies Measures

a. Federal Responsibility

i. Set More Stringent Emission Standards for New Harbor Craft and Ocean-Going Ships

Time Frame: Adopt 2003-2004; Implement 2008-2010

Responsible Agency: U.S. EPA

Proposed Strategy:

As discussed previously, the IMO and U.S. EPA have adopted exhaust emission standards for new marine diesel engines. However, the current standards in these regulations fall far short of the emission reductions possible with currently available emission control technology. In addition, the emission reductions achieved by the standards for oceangoing ships will be overwhelmed in California due to the rapid growth in the marine shipping industry, particularly from trade with Asian. Failure to implement more aggressive new engine standards will jeopardize California's ability to meet federal air quality standards, and will place increasing burdens on land-based emission sources that have already implemented controls. In addition, local Port authorities will face even more intense pressure to reduce their diesel particulate matter emissions and the associated risk on surrounding communities.

ARB has identified three regulatory avenues that U.S. EPA could pursue to achieve additional emission reductions: 1) pursue more stringent IMO standards for all commercial marine vessels over 130 kW (174 hp), 2) adopt more stringent U.S. EPA standards for harbor craft over 37 kW (50 hp), and 3) adopt more stringent U.S. EPA standards for U.S. and foreign-flagged ocean-going ships with Category 3 engines. In all cases, ARB is proposing new engine standards for NOx based on the federal Tier 2 and Tier 3 off-road standards, and PM standards based on state-of-the-art technology. The technologies that can be used to achieve these standards are described under each of the regulatory options below. U.S. EPA's own staff reports also describe technologies that can be used to achieve emission reductions far below the existing IMO NOx limits. For example, the draft regulatory document on the Category 3 engine rule (dated April 2002) lists several engine and fuel injection design modifications that U.S. EPA staff and engine manufacturers agree could achieve a 30 percent NOx reduction below IMO limits. In addition, further reductions of 50 to 80 percent are possible through the use of cleaner fuels, selective catalytic reduction, and technologies that introduce water into the combustion chamber, as discussed in the draft and final

U.S. EPA staff reports on Category 3 engines. We strongly encourage U.S. EPA to develop standards based on the use of these technologies when drafting 2007 standards for Category 3 engines (as well as for future effective standards for harbor craft engines).

Given the importance of regulating emissions from ocean-going ships, both in California and other U.S. states, ARB also encourages U.S. EPA to work to identify innovative strategies in addition to traditional approaches to achieving emission reduction targets. For example, ARB encourages U.S. EPA to work with shipping companies to develop MOUs that would encourage faster turnover of older ships or provide an incentive for shipping companies to send their cleaner ships to ports with greater air pollution problems. ARB also suggests that U.S. EPA work with manufacturers of Category 3 engines (i.e., large engines used on ocean-going ships). They could discuss agreements that would help accelerate the turnover of older ships, encourage the development of retrofit kits that could be installed (especially during rebuilding operations) to lower emissions from existing engines, and the manufacture of new engines exceeding IMO requirements.

IMO Standards: This concept calls on U.S. EPA to work with the IMO to seek future effective standards for NOx+HC and PM. Internationally recognized marine engine standards represent the most desirable form of regulation, particularly for oceangoing ships that travel to ports under many jurisdictions. The current IMO standards only apply to NOx, and range from 9.8 to 17 g/kW-hr, based on engine speed. These standards would achieve minimal emission reductions in California, especially from large cargo ships with slow speed two-stroke engines subject to the maximum 17 g/kW-hr standard.

ARB suggests future effective NOx+HC standards similar to the federal Tier 2 and Tier 3 off-road future-effective standards, which range from 4 to 6.4 g/kW-hr. Depending on the engine design, these standards can be met using a variety of technologies (alone or in combination), including: cleaner fuels, advanced fuel injection controls (common rail injection systems), combustion chamber design changes, injection timing retard, turbocharging and aftercooling, exhaust gas recirculation, selective catalytic reduction, direct water injection, and humid air motor technology.

For PM, ARB recommends considering a standard of 0.03 g/kw-hr for four-stroke engines (harbor craft), and 0.10 g/kW-hr for two-stroke, slow speed engines (ocean-going ships). For four-stroke harbor craft engines with access to low sulfur (15 ppm) diesel, this standard could be met by many engines with the use of catalyzed diesel particulate filters (DPFs). For other harbor craft and ocean-going ships with large two-stroke, slow speed engines, other technologies could be utilized (in some cases in combination or along with alternative fuels). These technologies include: active/noncatalyzed DPFs, fuel-borne catalysts, diesel oxidation catalysts, and advanced fuel injection controls (common rail injection systems). Manufacturers of large slow-speed two-stroke engines are also investigating additional PM techniques, such as specialized scrubber designs.

Although the proposed limits would be challenging to manufacturers, they are still higher than the 2007 standards for on-road heavy-duty diesel trucks at about 0.2 g/hp-hr NOx and 0.01 g/hp-hr PM. ARB expects implementation could begin in 2010.

National Harbor Craft Standards: This concept would rely upon U.S. EPA to develop another tier of more stringent standards for new harbor craft engines. As suggested for the IMO standards, ARB recommends future effective NOx+HC standards similar to the federal Tier 2 and Tier 3 off-road future-effective standards, which range from 4 to 6 g/kW-hr, based on engine size. For PM, ARB recommends a standard of 0.03 g/kW-hr. Implementation could begin three years after implementation of the current 2004-2007 standards (from 2007-2010).

U.S. EPA Standards for Ocean-Going Vessels: As mentioned previously, U.S. EPA promulgated final exhaust emission standards for new diesel engines at or above 30 liters per cylinder ("Category 3" engines) on February 28, 2003 (68 FR 9745). Under this rule, new Category 3 engines built in 2004 or later on U.S.-flagged vessels would be subject to the IMO NOx standards adopted in 1997.

Unfortunately, the rule will not achieve significant emission reductions because manufacturers are already making IMO compliant engines. In addition, the vast majority of ocean-going ships calling on California's ports are foreign-flagged vessels. Therefore, consistent with the first two proposals, this measure relies upon U.S. EPA to adopt NOx+HC standards based on the federal Tier 2 and Tier 3 off-road diesel standards for NOx HC (4 to 6.4 g NOx/kW-hr), and a 0.10 g/kW-hr standard for PM. Under the proposed measure, both foreign and U.S.-flagged vessels would be subject to the proposed standards beginning in 2008.

<u>Emission Reductions</u>

The estimated emission reductions from this strategy are shown in Table II-G-7. The estimate reflects adoption of U.S. EPA standards for both harbor craft and ocean-going vessels. The estimated reductions for ROG assume that the PM and NOx control strategies utilized to meet the proposed standards will also result in 90 percent control of ROG emissions. Significant further reductions beyond 2020 would also occur as new engines continue to replace existing vessels.

Table II-G-7
Set More Stringent Emission Standards for
New Harbor Craft and Ocean-Going Ships
Estimated Emission Reductions in the South Coast Air Basin
(Summer Planning, tpd)

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
ROG	Not Applicable	Not Applicable	Not Applicable	0.4	3.3
NOx	Not Applicable	Not Applicable	Not Applicable	3.1	29.1
PM10	Not Applicable	Not Applicable	Not Applicable	0.3	2.8

ii. Pursue Approaches to Clean Up the Existing Ocean-Going Ship Fleet – Cleaner Fuels, Incentives for Cleaner Ships, Smoke [Opacity] Limits

Time Frame: Adopt 2003-2005; Implement 2005-2010

Responsible Agency: U.S. EPA

Proposed Strategy:

Under this concept, U.S. EPA would reduce in-use emissions from ocean-going vessels. Achieving emission reductions from the in-use vessels is critical because marine diesel engines often provide service for 20 to 30 years. Therefore, even if more stringent new engine standards are adopted in the next few years, the emission reductions achieved in 2010 will be relatively minor due to the slow turnover of existing engines.

We expect that U.S. EPA would work closely with the maritime industry, ARB, the local districts, and other stakeholders on this measure. This collaboration is particularly critical for this measure since the majority of ocean-going ships frequenting California coastal waters are foreign-flagged vessels. Implementation of measures for ocean-going vessels may even require the formation of a national or international coalition, particularly for some of the proposed federal incentive programs (which would be more effective if implemented on a national or West Coast basis). ARB staff believes the options under this measure could be implemented in the 2005-2010 timeframe.

As a starting point, ARB staff has identified five emission reduction strategies that U.S. EPA should evaluate for applicability to ocean-going ships, including foreign-flagged vessels. The five proposals ARB has identified are:

- Operational controls
- Cleaner fuels in California coastal waters
- Incentive programs to encourage cleaner vessels
- Opacity limits within California coastal waters
- Cold Ironing (Electrical power for hotelling)

Operational Controls: Operational controls can provide emission reductions through a broad array of potential measures, including speed controls, idling time limits, and other changes to vessel activities. For example, U.S. EPA assisted in the development of a voluntary speed reduction demonstration project that was initiated in May 2001 at the ports of Los Angeles and Long Beach. The Memorandum of Understanding (MOU) that initiated the project calls for ocean-going vessels entering or leaving the ports to slow to 12 knots within 20 nautical miles of the ports. The speed reduction results in lower engine speeds, power, and associated NOx emissions. Upon full implementation, the MOU is expected to result in an emission reduction of two to four tons of NOx per day in the South Coast Air Basin.

Cleaner Fuels: Under this option, ocean-going vessels would use cleaner burning fuels in California coastal waters. Currently, most ocean-going ships visiting the ports of Los Angeles and Long Beach use bunker fuels (such as intermediate fuel oil (IFO) 180, or IFO 380) with an average sulfur content of about 2.8 percent (28,000 ppm). On-board generators use marine diesel fuel (also called marine gas oil or MGO) or bunker fuel, depending on the vessel. Under this option, several opportunities exist to use cleaner fuels, such as requiring generators to run on California on-road diesel fuel in California coastal waters. It may also be possible for propulsion engines to switch to California on-road diesel fuel (or standard MGO, or lower viscosity and/or lower sulfur bunker fuel). Currently, many ocean-going ships switch to MGO for maneuvering at or near the ports, so it may be possible to extend the use of MGO to California coastal waters. The PM and NOx emission reductions achieved by switching from bunker fuel to MGO would be expected to be 44 percent and 10 percent, respectively. Even further reductions would be expected with the use of California on-road diesel fuel. For example, the PM and NOx emission reductions achieved by switching from MGO to California on-road diesel would be expected to be at least 25 percent and 7 percent, respectively (the reductions expected by switching from U.S. EPA on-road to California on-road diesel). There would also be a dramatic reduction in the sulfur content of the fuel and associated reductions in SOx emissions. For example, California on-road diesel currently averages about 140 ppm sulfur, compared to 28,000 ppm for bunker fuels. The introduction of cleaner, lower sulfur fuels would also enable the use of a wider range of control technologies to be used on either the propulsion or auxiliary engines.

International availability of the cleaner fuels mentioned above and separate fuel storage options will be issues that will need to be addressed in considering these options. However, other countries have successfully taken steps to encourage the use of lower sulfur fuels. At a minimum, U.S. EPA should work with the International Maritime Organization to create a sulfur emission control area (SECA) along the West Coast under the existing provisions of MARPOL Annex VI. An existing SECA covering the Baltic Sea limits sulfur content to 1.5 percent (15,000 ppm).

***Economic Incentive Programs that Reward Cleaner Ships*:** Economic incentive programs could be implemented to encourage ocean-going vessel owners to reduce the emissions from their ships. Under this option, a full evaluation of potential incentive programs would be explored – both existing programs and new programs that would be identified and evaluated with help from the maritime industry. Efforts would be directed to identifying the ships that will produce the greatest reductions for the dollars spent. Federal incentive programs could include programs which help finance the incremental cost of purchasing cleaner engines (compared to standard replacement engines) or installing pollution control equipment.

Another option would be a differential port fee structure under which cleaner vessels are charged lower fees. For example, in Sweden, several ports have implemented a port fee system that offers discounts for ships emitting lower NOx emissions and using lower sulfur bunker fuels. The loss in revenue from the discounted fees is compensated for by slight increases charged to higher emitting ships. Finnish and Norwegian ports have proposed or implemented similar programs which reduce port fees or taxes for cleaner vessels.

Federal incentive programs would have a greater degree of success if implemented throughout the West Coast or nationally since most of the emissions from ocean-going ships will be emitted beyond California's boundaries, and the cost of emissions control is high for these very large diesel engines. Therefore, participation by a national coalition may be necessary in implementing an incentive program for ocean-going ships.

Currently, ARB staff is working with U.S. EPA, the Maritime Administration, and several other regulatory agencies, shipping operators and port representatives to provide funding for demonstration projects that will test emission control technologies on ocean-going ships. It is expected that successful demonstration projects will support federal economic incentive programs by providing information on the feasibility of currently available technologies.

Opacity Requirement for Vessels in California Coastal Waters: Under this option, U.S. EPA would evaluate restrictions on opacity for vessels in California coastal waters. As an example, Alaska has established a requirement that cruise ships operating within 3 miles of the coastline cannot release emissions that reduce visibility by more than 20 percent (18 Alaska Administrative Code 50.070). To meet this requirement, cruise lines have employed a variety of techniques, including the use of fuel additives, lower viscosity bunker fuel (IFO 180), operational changes, and increased maintenance schedules. Cruise lines have also installed cleaner engines on some ships. For example, some cruise lines have installed combinations of both diesel electric and gas turbine-electric engines in their ships. With this arrangement, the ship owners can operate without visible emissions by using the gas turbine alone, or operating the diesel piston engines at constant high load and letting the gas turbine handle the variations. Engine manufacturers have also responded to the challenge by manufacturing new “smokeless” diesel engines using common-rail fuel injection.[1]

Depending on the type of opacity limits ultimately proposed, vessel operators may be able to use some of the same techniques used by the cruise lines to meet Alaska’s opacity limit. In addition, clean fuel options such as those discussed previously in this chapter may be feasible.

Cold Ironing: Marine vessels typically run diesel generators when at rest in port (hotelling) to generate electrical power for lights and equipment on board. These diesel generators are a significant contributor to diesel PM and NOx emissions at major ports in California. Under this proposed option, ships would use dockside electrical power (cold ironing) during hotelling. For dockside electrical power, the power plant emissions associated with providing dockside power would be a fraction of the emissions from a marine auxiliary engine. For example, the NOx emissions per megawatt-hour from a diesel generator would be roughly 100 times greater than the emissions from power plants supplying electricity to California’s utilities.

Although there are technical challenges associated with providing cold ironing for ships, this process is currently being used by Princess Cruise ships that dock in Juneau, Alaska. The Alaska Electric Light and Power Company (AEL&P) and Princess Cruises joined forces to construct a shore-side power station that provides up to 13 megawatts of hydroelectric power produced by AEL&P. The Port of Los Angeles is also investigating this option with several Asian cargo ship operators and the Los Angeles Department of Water and Power.

The estimated emission reductions from this concept are shown in Table II-G-8. The emission reductions reflect a 10 percent reduction in NOx, PM10, and ROG beginning in 2005 and a 25-40 percent reduction in these pollutants beginning in 2010.

[1] Marine News, Wartsila Corporation, October 2001

It is expected that these emission reductions would be achieved by implementing several of the options discussed above. The reductions also reflect the anticipated implementation of the new emission standard strategy described above.

Table II-G-8
Pursue Approaches to Clean Up the Existing Ocean-Going Ship Fleet
Estimated Emission Reductions in the South Coast Air Basin (Summer Planning, tpd)

Pollutant	2005	2006 (Annual Average)	2008	2010	2020
ROG	0.4	0.4	0.4	1.0-1.6	0.7-1.1
NOx	4.1	4.2	4.5	11-17.6	10.2-16.4
PM10	0.3	0.3	0.4	0.8-1.3	0.6-0.9

CHAPTER H

Aircraft and Airports

CHAPTER H. AIRCRAFT AND AIRPORTS

This chapter discusses aircraft as well as other sources that are located at or access the airport—ground service equipment (GSE) and ground access vehicles. Turboprops, smaller business jet aircraft, and piston engine aircraft, which include all propeller driven aircraft, make up only a small percentage of aircraft emissions and are not addressed in this chapter.

The primary pollutants emitted by jet aircraft engines are ROG, NOx, CO, PM10, and CO2. Jet aircraft also emit a host of toxic compounds, including 1,3-butadiene and formaldehyde.

1. Category Description

The emission sources of concern at the airport are divided into three categories: jet aircraft, ground service equipment, and ground access vehicles.

a. Jet Aircraft

Jet aircraft are a growing source of emissions at California's commercial airports due to the large increase in air travel. Jet aircraft are long-lived, with the average economic life of a passenger aircraft on the order of 28 years and up to 40 years for all-cargo aircraft. (Cargo aircraft last longer because they undergo fewer landing and takeoff cycles and accumulate less annual operational hours than passenger jets.) The long lives of these emission sources underscore the need for more stringent emission standards for jet aircraft.

Like any motorized vehicle, aircraft produce emissions as long as the engine is running or idling. However, the aircraft operations of most concern for a nonattainment area are those that occur during takeoff, landing, approach, climb-out, and taxiing.

Fuel is a major operating expense for airlines; therefore, airlines have and continue to put a high priority on fuel-efficient engines. Since 1975, on a per passenger mile basis, the airline industry has experienced 75 and 20 percent reductions in ROG and CO2 emissions, respectively, due to increased fuel efficiency. However, NOx emissions from new engines introduced into service have been declining by only about one percent per year. This is due to the tradeoff that results when temperature and pressure in the engine's combustion chamber are increased to enhance fuel efficiency at the expense of NOx emissions.

The National Aeronautics and Space Administration (NASA) conducts most of the original research and development work on new turbine engine technology and has a multi-year program to develop lower emitting jet engines. One target is to introduce an engine that can emit 70 percent less NOx than the current International Civil Aviation Organization (ICAO) standard. Aircraft engine manufacturers have also been working to develop engines with lower NOx emissions while improving fuel efficiency. At issue is whether lower NOx engines will be available and introduced into the fleet in sufficient quantities to offset the emissions associated with the projected increase in air travel.

New noise standards that have been approved by ICAO but not yet promulgated by the Federal Aviation Administration (FAA) could also increase NOx emissions; however, advanced engine combustor technologies could reduce noise and future NOx emissions.

As with automobiles and trucks, most aircraft can be ordered with different models of aircraft engines, each potentially having different emission levels. When ordering an aircraft, an air carrier's first consideration is to ensure the engine matches the operational requirements intended for the aircraft. In addition, previous contractual agreements or desire for fleet consistency can influence selection of a particular engine model. A national aircraft emissions reduction stakeholders group has discussed various potential aircraft emission reduction measures; one would be to have air carriers commit to order new aircraft with engines having the lowest emissions certified for that aircraft consistent with its intended mission. Further evaluation could help determine the full extent of opportunities for achieving lower NOx emissions through such purchases and identify potential pollutant tradeoffs that could occur.

Some airports have also been exploring means for reducing aircraft emissions. Airports in Zurich, Switzerland and Boston, Massachusetts are pursing revenue-neutral emission based landing fees that provide lower emission fees for lower emitting aircraft and, conversely, higher fees for higher emitting aircraft. Such fee systems are intended to provide air carriers an incentive to purchase and operate aircraft with lower emission engines.

As noted above, the aircraft emissions of most concern to State Implementation Plans are those that occur when aircraft are operating at an airport or during takeoff and approach. Thus, ground-based operational practices provide potential opportunities for emission reductions. These include having aircraft reduce multi-engine taxiing on the runway, having aircraft use the electricity at the gates instead of the auxiliary power unit on the aircraft to provide power while parked at the terminal, and having the airport provide efficient taxiway configurations to reduce aircraft congestion. There are a number of operational measures in the "tool box," but many are totally dependent on aircraft pilot judgment as to what is safe and feasible in each particular situation. Nevertheless, these strategies have resulted in meaningful and cost-effective emission reductions in the past and could potentially provide more.

Aircraft engine exhaust also contains PM; however there are limited data on the specific components of the PM in the exhaust at this time. Although jet fuel is chemically similar to diesel fuel, ARB has not been able to determine whether aircraft exhaust PM has similar toxicity as diesel exhaust PM. The highest PM emission rates occur during high power operations of takeoff and climb-out when there is high fuel consumption. Because these operations occur at or near airports, communities located adjacent to airports have raised concerns about the potential risk from exposure to toxic compounds.

b. Ground Service Equipment

Ground service equipment (GSE) are specialized off-road equipment that perform a variety of functions in support of aircraft operations including aircraft towing, maintenance, fueling, baggage handling, cargo loading, and food service. They are largely uncontrolled with typically long vehicle and equipment life. To reduce costs, airlines frequently rebuild GSE engines, thereby extending the life of the older, higher polluting units, rather than purchase new, lower polluting equipment. Engine deterioration, along with aging equipment and parts, increases ROG, NOx, and PM emissions. Another contributor to high GSE ROG and diesel PM emissions is extended engine idling. GSE use is primarily a function of the number of aircraft takeoffs and landing. To the extent that airline traffic and total annual passengers increase, GSE equipment and usage will also increase – as will emissions.

c. Ground Access Vehicles

Ground access vehicles move airport passengers, employees, and goods to, from, and around the airport. These vehicles include private passenger vehicles, airport shuttles, taxis, hotel shuttles, parking shuttles, cargo vehicles, and tenant and employee vehicles.

Ground access emissions at airports are not accounted for separately in ARB emission inventory. Rather, these emissions are included within other motor vehicle emission source categories. Ground access emissions vary by airport and surrounding land uses. However, traffic-related NOx emissions can be as high as 50 percent of total airport-related NOx emissions and ROG as much as 80 percent of the total.

Strategies to reduce emissions from ground access vehicles take several different forms because of the variety and ownership of the vehicles involved. Following are examples of strategies to reduce ground access vehicle emissions that are (or could be) implemented by California airport operators.

<u>Reduce Emissions from Airport Vehicles</u>: Some airport operators are reducing emissions from their own vehicle fleets, through the acquisition of either ZEVs or

alternate fuel vehicles. A number of airports are already moving in this direction with CNG and LNG shuttle buses. Another option is purchase of ULEV or SULEV models where available when replacing fleet vehicles. The airport could also reduce diesel PM emissions by retrofitting diesel vehicles with PM filters or to purchase new diesel vehicles equipped with a PM filter.

Provide Alternative Fuel/Electric Infrastructure: By providing fueling and charging infrastructure, airports can facilitate use of ZEVs and alternative-fuel vehicles. Some examples include alternate fuel dispensers for airport owned vehicles, availability of alternate fueling facilities for non-airport vehicle operators at consolidated facilities or at downtown airport shuttle terminals, or people movers to reduce vehicle trips. The magnitude of associated emission reductions would be dependent on the exact nature of the infrastructure.

Transportation Options: Consolidating and streamlining on-airport vehicle travel can reduce emissions and decrease public exposure to toxics at terminals. For vehicles not owned by the airport, there is a mix of fee adjustment, incentive, and public education programs. Because airports vary in the way they operate and their specific operating authority, programs would need to be tailored to each airport's specific situation.

Cleanest Vehicles: Airports could require shuttle and taxi fleet operators to operate fleets with progressively higher percentages of new vehicles or those meeting optional low emission standards, such as ULEV or SULEV vehicles. Another program would have airports that have the authority charge variable access fees consistent with the emissions level of the vehicle. The overall objective would be to require or provide incentives to fleet operators to reduce emissions at a faster rate than would occur with "normal" fleet turnover or company purchase policies.

Viable Alternative Ground Transportation Choices: In order to reduce off-airport vehicle emissions, airports could provide travelers with more viable ground transportation options, and also provide commute programs for airport employees.

The airports could promote airport and airport tenant employee commute programs, including lower parking rates and priority parking for carpoolers, an airport-sponsored integrated employee clean fuel shuttle system, an employees' carpool and vanpool matching system, and subsidized or free employee transit and shuttle fares.

Offsite park and ride or "fly away" lots also can reduce vehicle trips to the airport and relieve airport congestion and localized CO emissions. The Van Nuys FlyAway terminal checks people in and then express buses them to the main terminal at Los Angeles International Airport. The magnitude of the emission reductions from these facilities would depend on their location, number of trips offset, and the emission characteristics of airport shuttles. The success of such measures would also be highly dependent on a close collaboration with local and regional transportation planning agencies and transit authorities. Long range transit service plans for the region would need to consider providing adequate service to the airport.

Public Education: Finally, public education is a critical component to any airport transportation program. The public needs to be fully aware of the various modes of travel available to the airport and the economic and environmental benefits of one mode versus another.

2. Emission Trends[1]

The baseline and projected emissions from aircraft and ground support equipment are shown in Table II-H-1. Between 1980 and 1999, commercial air passengers increased by about 125 percent nationally and more than doubled in California. Air cargo tonnage is growing more rapidly than air passengers, at nearly six percent per year, a rate that is expected to continue through 2012.

Table II-H-1
Baseline Emissions for Aircraft/Airports
(South Coast, Summer Planning, tpd)

Pollutant Source Category	2000	2010	2020
ROG			
Aircraft	**6.1**	**5.4**	**7.1**
-Commercial	1.9	2.8	4.4
-Military	3.5	1.9	1.9
-General Aviation	0.7	0.7	0.8
Ground Service Equipment	**1.0**	**0.5**	**NA**
NOx			
Aircraft	**23.1**	**32.1**	**40.1**
-Commercial	21.7	29.2	37.3
-Military	1.3	2.8	2.8
-General Aviation	0.1	0.1	0.1
Ground Service Equipment	**6.9**	**3.2**	**NA**

1 The emissions estimates provided do not reflect the impact of events on September 11, 2001. Air travel dropped dramatically in the short term and nearly all air carriers experienced severe financial setbacks. Air carriers have responded by reducing the number of flights, retiring older, less efficient aircraft, and generally scaling back operations in an effort to cut expenses. Air travel in the long term is expected to increase, although whether air travel returns to pre-September 11 growth rates or lower-than-earlier-projected rates remains to be seen.

Over the past 25 years, national commercial aircraft emissions increased 25 percent for ROG and 66 percent for NOx. In California, aircraft emissions of ROG plus NOx in 2000 were about two percent of all mobile source ROG plus NOx emissions. However, by 2020, this percentage is expected to more than double. Newer (and cleaner) aircraft engines continue to be introduced into the fleet. Nevertheless, without additional measures, emission "benefits" will be more than offset by the increase in the number of aircraft and flights needed to accommodate an estimated 75 percent increase in air passengers and more than a doubling of air cargo tonnage by 2020.

Military aircraft also represent a significant source of emissions, although trends show that these emissions are expected to remain relatively constant in the foreseeable future.

ARB does not currently have detailed emission inventory data by source type at individual airports. Data from airport master plans and expansion project environmental documents indicate that on-airport stationary and area source emissions are typically one to three percent of total on-airport emissions, excluding aircraft maintenance emissions. If aircraft maintenance operations are conducted at an airport, then stationary and area source emissions can be up to five to six percent of total on-airport emissions.

One of the future mechanisms to reduce the growth in aircraft emissions is to establish alternative travel options that use cleaner technology. The planned California high-speed train system offers the potential to significantly reduce emissions across the State, including San Francisco, Sacramento, San Joaquin Valley, South Coast, and San Diego. A high-speed train system would provide air passengers with an alternative to interstate or local air flights in California as well as connecting links to major airports and rail systems.

The California High-Speed Rail Authority, a nine-member appointed board, is the State entity responsible for planning, constructing, and operating a 700 mile high-speed train system serving all of the State's metropolitan areas by 2020. Recently, the Legislature eliminated the Authority's December 31, 2003 sunset date; included in the 2002-2003 State budget is $7 million dollars in funding for the first step of the system – completion of a program-level State and federal environmental review. The final environmental document will be completed by December 2003.

Governor Davis signed legislation on September 19, 2002 that places a $10 billion general obligation bond measure on the November 2004 ballot. This bond would fund the planning and construction of the first phase of the system—connecting Los Angeles with the Bay Area. The second phase of the program, taking about four years, will include a project-specific environmental analysis and preliminary engineering design that would be completed around the end of 2007. Final design and construction of the starter system could be completed within seven years, with the entire system completed within about ten years.

When fully operational in 2020, the system could have an estimated 32 million passengers annually for the base case and up to 55 million annual passengers if air and automobile travel growth rates, air and automobile travel times, and air fares increase. About 45 percent of high-speed train passengers could be diverted from air transportation; thus, substantial emission reductions could occur in the South Coast, as well as Bay Area, San Diego, and Sacramento airports. Approximately half of these benefits could occur in the South Coast Air Basin, since it will be the origin or destination of the majority of trips diverted from air transportation.

3. Existing Control Program

The ICAO, U.S. EPA, ARB, and local air districts have programs to control emissions from airport-related sources.

a. Aircraft Engines

ARB is pre-empted from adopting jet aircraft engine emission standards. Under federal law, that right is reserved for U.S. EPA. In practice, U.S. EPA works its standard-setting process through ICAO because aircraft engines are international commodities and jet aircraft frequently operate internationally. ICAO was created in 1944 by the Convention on International Civil Aviation (the "Chicago Convention"). ICAO's responsibilities include developing aircraft technical and operating standards, recommending practices, and generally fostering the growth of international civil aviation. Over 180 nations participate in the organization, including the United States. ICAO develops aircraft engine standards through its Committee on Aviation Environmental Protection (CAEP).

Since 1998, U.S. EPA and FAA have jointly sponsored a national stakeholder group whose goal is to define emission reduction targets for air carriers that include a longer term (post-2010) goal for reductions in jet aircraft emissions. One objective of this process is for ICAO to develop more stringent aircraft emission standards.

U.S. EPA historically has not required military aircraft engines to meet its aircraft emission standards, although the Clean Air Act does not prohibit U.S. EPA from doing so. In areas that have military aviation facilities, emissions from military aircraft can be significant and pose opportunities for reductions if they would be required to comply with U.S. EPA aircraft emission standards.

Current jet aircraft engine standards are listed in Table II-H-2. The net effect of the form of the NOx standard is to allow larger engines with higher pressure ratios to emit more NOx per unit of rated thrust. In addition to the complex form of the NOx standard, aircraft engine emission standards differ from motor vehicle emission standards in that aircraft standards sometimes apply only to newly designed engines, not to all engines manufactured after a specified year.

Table II-H-2
Current U.S. EPA Emission Standards for Jet Aircraft Engines
(grams per kilonewton of thrust*)

Pollutant	Standard
CO	118
HC	19.6
NOx	32 + 1.6 x engine pressure ratio

*Thrust is rated output or maximum thrust required for takeoff

ICAO has recently approved a new standard that will apply starting in 2004 and is being proposed for promulgation by U.S. EPA. Again, the standard is written to allow higher-pressure ratio engines to have higher NOx emissions. The new standard will require NOx to be reduced by 16 percent for the smaller, lower pressure ratio engines. However, for the larger, higher-pressure ratio engines, the new standard requires less reductions as the engines get larger with no reductions for the largest ones. Because most new aircraft engines are being designed with higher-pressure ratios, the net effect of the new standard would be minimal change in per aircraft-related NOx emissions. The U.S. and a number of European countries have expressed strongly the need for aircraft NOx emissions reductions, which has prompted ICAO to begin work on a new, more stringent NOx standard.

b. Ground Service Equipment

Both U.S. EPA and ARB's on-road and off-road motor vehicle emission standards apply to GSE used in airport operations. Additional information on these standards can be found in the chapters dealing with off-road compression-ignition engines and off-road large spark-ignition engines.

A joint effort by U.S. EPA and ARB resulted in lower emission standards for new off-road equipment, however, additional measures are needed to reduce GSE-related emissions from existing units. Air carriers have historically elected to rebuild GSE engines rather than to replace the units with new, lower emitting equipment. The greatest emission reduction would come from accelerated fleet turnover.

In addition, an enforceable agreement has been negotiated with air carriers to replace older GSE with lower or zero emitting units. The agreement, referred to as the

GSE Memorandum of Understanding (MOU), is a joint effort among ARB, U.S. EPA, South Coast District, and the 17 Air Transport Association-member airlines that operate at the five commercial airports in the South Coast Air Basin. The MOU will require the air carriers to reduce their 1997 GSE fleet-average (ROG+NOx) emissions by approximately 80 percent by 2010. The MOU does not specify how the airlines are to achieve these reductions, however, the calculation of the 80 percent reduction was predicated on the accelerated turnover and replacement of between 30 to 40 percent of existing equipment with ZEVs. Another 40 percent of the GSE fleet would need to be repowered, retrofitted, or replaced with new equipment that meet lower emission standards.

The MOU also requires air carriers to reduce diesel particulate emissions by installing filters or oxidation catalysts on phase-in schedules that depend on the type and age of the equipment. The MOU requires the use of 15 ppm sulfur diesel fuel after December 31, 2003.

The MOU deals separately with the "growth fleet" (units added to the fleet after 1997 to accommodate growth). Forty-five percent of growth units must be ZEVs, excluding four categories of GSE. The MOU also requires that all non-ZEV units added to the GSE growth fleet must have certified engines that comply with emission standards in place on the date the equipment begins service at the five airports. The requirement will ensure that older, higher-emitting units are not transferred from outside the region.

The requirements in the GSE MOU apply only to those GSE owned and operated by the 17 air carriers that are member of the Air Transport Association that operate at airports in the South Coast Air Basin. International air carriers and regional air carriers that contract with private GSE companies to provide required services at airports are not covered by the GSE MOU. These contractors own and operate approximately 17 percent of all the GSE. Los Angeles World Airports (LAWA) staff has recently begun to renegotiate access leases with businesses operating at the airport. LAWA staff intends to condition the leases to require all entities owning and operating GSE to meet the requirements in the GSE MOU. There may be opportunities for further reductions from GSE at other airports in the region if these airports are able to utilize access leases or similar means for extending the requirements in the GSE MOU to all GSE operating in the South Coast Air Basin.

Major elements of the MOU are described in more detail below. Table II-H-3 presents expected emission benefits of the MOU.

Reduction in ROG + NOx Fleet Average Emissions: The first element requires the carriers to reduce the fleet average emissions of ROG + NOx from their 1997 GSE fleet to 2.65 grams/brake-horsepower/hour between 1997 baseline levels and 2010. This represents an 80 percent reduction. It is based on a high penetration of existing ZEV technologies into the existing GSE fleet as well as the accelerated purchase of new fossil-fueled engines that meet ARB and U.S EPA's most stringent standards for off-road equipment.

Zero Emission GSE Vehicles: The second element requires that a minimum of 30 percent of the 1997 fleet GSE be ZEVs in 2010. Because ZEV technology is already a commercial success for baggage tractors and belt loaders, the MOU anticipates that a very high percentage (85-90 percent) of these GSE will be ZEV in 2010. Other GSE categories, such as aircraft pushback tractors, are less advanced, have some ZEV models, and show promise for commercial development of improved electric battery-powered drives. The MOU also requires that 45 percent of the GSE added to fleet for growth purposes be ZEV, with the exception of four categories of GSE that are not amenable to electrification.

Electric Infrastructure: To support the MOU requirement that the air carriers have ZEV GSE by 2010, the airports will need to ensure there is adequate infrastructure for electric GSE where such infrastructure does not exist. Gate electrification to support GSE recharging and that provides electricity and preconditioned air for parked aircraft is becoming more common with new gates and terminals. However, full-scale gate electrification is needed to ensure zero-emitting GSE can be used, and to preclude the need for using the aircraft's turbine auxiliary power unit.

Table II-H-3
Emission Benefits of Ground Service Equipment MOU
Estimated Emission Reductions in 2010
(South Coast, Summer Planning, tpd)

Pollutant	Reduction
ROG	0.3
NOx	1.5

c. Ground Access Vehicles

ARB's motor vehicle emission program will cut ROG plus NOx emission rates per vehicle mile by about 85 percent over the next twenty years. Growth in air travel, however, could lead to increases in motor vehicle emissions through the increase in the number of airport-related trips, unless there is a shift to higher occupancy vehicles, e.g., taxicabs, passenger shuttle buses, and local transit.

Trip reduction strategies are primarily the domain of local jurisdictions. ARB has been able to require modest ground access-related emission reduction measures through the air quality certification process. This process conditions federal funding of certain airport projects (new airports, new runways, or major runway extensions) on ARB's certification that the project will not interfere with the attainment or maintenance of air quality standards. Under this process, an airport applying for certification must commit to implement all feasible measures to reduce emissions, including emissions from ground access and GSE. An example of ARB certification conditions is requiring an airport to purchase or lease low-emission on-airport shuttle buses that meet or exceed ARB's emission standards for new buses.

4. Long-Term Advanced Technologies Strategies

One approach to reduce emissions from airports is to reduce emissions from vehicles traveling to and from airports. Ground access vehicles move airport passengers, employees, and goods to, from, and around the airport. These vehicles include private passenger vehicles, airport shuttles, taxis, hotel shuttles, parking shuttles, cargo vehicles, and tenant and employee vehicles.

Strategies to reduce emissions from ground access vehicles could take several different forms because of the variety and ownership of the vehicles involved. Specific ideas include reducing emissions from airport fleet vehicles using alternative fuels, or particulate diesel filters; providing an infrastructure for alternative fuel/electric vehicles between airports and shuttle terminals; consolidating on-airport vehicle travel; emissions-based airport entry fees for cabs and other shuttle vehicles; and increased ground transportation options for both passenger-bound and employee commuting to and from the airport.

a. Federal Responsibility

i. Pursue Approaches to Reduce Emissions from Jet Aircraft – More Stringent Engine Standards, Retrofit Controls, Cleaner Fuel, Apply Standards to Non-Tactical Military Aircraft

Time Frame: Adopt 2004-2009; Implement 2008-2015

Responsible Agency: U.S. EPA

Proposed Strategy:

The proposed approaches for U.S. EPA to cut emissions from new and existing jet aircraft would provide some benefit by 2010, growing over time to help mitigate the net increase in aircraft emissions. Some concepts require new technology, new standards, and considerable investments in research and development funding by NASA, airframe manufacturers, and jet aircraft engine manufacturers. U.S. EPA has the responsibility to reduce emissions from jet aircraft.

Lower-Emission Aircraft Engines: This concept calls for more stringent aircraft emission standards and the development of lower-emission aircraft engines. U.S. EPA could work with FAA and ICAO to adopt lower emission standards for: VOC, to reduce both ozone and toxic compounds; PM, to reduce fine particles and potentially toxic compounds; and NOx. The NOx emission standards should reflect at least a 50 percent reduction in per-engine NOx emissions from current standards (known as "CAEP/2 standards") for all engines for which the date of manufacture of the first individual production model is after 2007. In addition, a longer-range standard of a 70 percent reduction in per-engine NOx emissions from current standards should be adopted for implementation in the 2010-2015 timeframe. These concepts depend on substantial funding commitments by both governmental and industry partners to develop integrated component technology demonstrations leading to clean engine certification by 2007 to 2010.

Install Engine Emission Retrofit Kits: This concept calls for the purchase and installation of jet engine NOx emission retrofit kits where available and feasible. For example, a retrofit kit developed for Rolls Royce engines that power Boeing 757 aircraft reduces NOx emissions by about 30 percent over existing engines.

Reformulate Jet Fuel: U.S. EPA, with concurrence of FAA, has the authority to require the reformulation of jet fuel to lower the sulfur content. Sulfur contributes to PM emissions. Reformulation of diesel fuel and gasoline have resulted in significant emission reductions for on- and off-road motor vehicles. Because of potential benefits for reduced PM emissions, reformulating jet fuel should be evaluated.

Apply Commercial Aircraft Engine Standards to Non-Tactical Military Aircraft: U.S. EPA could exercise its authority under the Clean Air Act to require non-tactical military aircraft to meet the same emission standards as the commercial aircraft engines. This concept could result in significant reductions, but cannot be quantified at this time.

Table II-H-5
Pursue Approaches to Reduce Emissions from Jet Aircraft
Estimated Emission Reductions in 2010
(South Coast, Summer Planning, tpd)

Pollutant	Reduction
ROG	0 - 0.5
NOx	0 - 1.8

CHAPTER I

Locomotives and Railyards

CHAPTER I. LOCOMOTIVES AND RAILYARDS

1. Category Description

Railroads operate national locomotive fleets that travel between states daily, currently moving more than 40 percent of the total intercity revenue ton-miles of freight in the United States. Rail networks are geographically spread across the country, serving every major city in the United States. Efficient train transportation is an important factor in the regional and national economy.

Locomotives are an environmentally efficient way to move goods. Railroads continue to improve their efficiency and reduce emissions per ton-mile by utilizing more efficient locomotives, improving freight movement operations, and other means. Currently, emissions per ton-mile of freight moved are lower for locomotives than for heavy-duty trucks. However, new on-road trucks will become significantly cleaner with the introduction of the 2007 emission standards. As heavy-duty truck standards become more stringent, railroads need to do more to improve locomotive emissions and remain an environmentally efficient choice to move goods.

Most of the emissions that occur in California from locomotives are from line haul locomotives that travel in and out of the State. About 67 percent of the locomotive exhaust emissions that occur in California are from interstate line haul operations; 20 percent are from local (short-line locomotive) operations that occur only in California; 10 percent are from switch yard operations; and the remaining 3 percent are from passenger trains. Although not quantified, locomotives used in industrial settings would also contribute a very minor amount of additional emissions. Baseline ROG, NOx, PM, and CO emissions from locomotive engines are listed in Table II-I-1 below.

The type of diesel fuel that is used by the railroads also affects in-use emissions but is not regulated. While railroads are allowed to use high-sulfur fuel (5,000 ppm max), most of the diesel fuel purchased by the railroads in California is either U.S. EPA on-highway grade diesel fuel – with an average sulfur content of 330 ppm (500 ppm max) – or California grade diesel with an average sulfur content of about 140 ppm (500 ppm max). High sulfur diesel fuel is not generally available for locomotive refueling in California. The major pipeline distribution system in California excludes high sulfur diesel fuel shipments in order to reduce sulfur cross contamination with other petroleum products. However, interstate locomotives entering California can be consuming fuel obtained outside of California which can have significantly higher sulfur content. The widespread use of the lower sulfur diesel fuels would result in lower PM emissions, and the use of California grade diesel fuel would also reduce NOx emissions.

Table II-I-1
Baseline Emissions for Locomotive Engines
(South Coast, Summer Planning, tpd)

Pollutant	2005	2006	2008	2010	2020
ROG	1.8	1.8	1.7	1.7	1.6
NOx	32	30	28	18	20
PM10	1.0	1.0	0.9	0.9	0.9
CO	6.6	6.7	6.8	7.0	7.9

Note: Reflects the benefits of the South Coast Memorandum of Understanding described below.

2. Existing Control Program

Section 209(e) of the federal Clean Air Act prohibits any state or local government from adopting or enforcing any standard or other requirement relating to the control of emissions from new locomotives and new engines used in locomotives. Locomotives last a very long time. It is typical for the railroads to remanufacture locomotives every seven years. During remanufacture, the engine can be rebuilt or replaced. To minimize future emissions from post-1972 model-year locomotives, U.S. EPA regulates new engines and the remanufacture of post-1972 units. California also has developed and implemented voluntary programs that are expected to reduce emissions from locomotives. The following subsections provide a brief description of existing programs for locomotives in California.

a. U.S. EPA Standards for Locomotives

In 1998, U.S. EPA adopted exhaust emission standards for NOx, HC, CO, PM, and smoke for newly manufactured and remanufactured locomotives and locomotive engines beginning in 2001 (Table II-I-2). The standards are being phased in and are based on the date of original manufacture. The federal Tier 0 standards set specifications for locomotive engines originally manufactured from 1973 to 2001. The Tier 1 standards apply to locomotive engines originally manufactured from 2002 through 2004, and the Tier 2 standards apply to locomotive engines originally manufactured in 2005 and later.

Table II-I-2
Federal Locomotive Exhaust and Smoke Emission Standards

Tier	NOx (g/bhp-hr)		PM (g/bhp-hr)		Smoke (Percent Opacity – Normalized)			HC (g/bhp-hr)	
	Line-haul duty-cycle	Switch duty-cycle	Line-haul duty-cycle	Switch duty-cycle	Steady-state	30 sec Peak	3-sec Peak	Line-haul duty-cycle	Switch duty-cycle
Tier 0 1973-2001	9.5	14	0.6	0.72	30	40	50	1.00	2.10
Tier 1 2002-2004	7.4	11	0.45	0.54	25	40	50	0.55	1.20
Tier 2 2005 and later	5.5	8.1	0.2	0.24	20	40	50	0.30	0.60

By comparison, U.S. EPA estimates uncontrolled locomotive emission rates for NOx are 13.0 and 17.4 g/bhp-hr for line-haul and switcher locomotive engines, respectively.

b. Memorandum of Understanding for Locomotives in the South Coast Air Basin

Although federal law preempts California from setting standards for new locomotives and new engines used in locomotives, ARB and the two Class 1 freight railroads operating in California have taken steps to further reduce emissions from locomotives within the South Coast. The federal Surface Transportation Board classifies those railroads with annual revenues of $261.9 million or more for year 2000 as Class 1 railroads. In 1993, these railroads proposed to U.S. EPA, ARB and others the establishment of a locomotive fleet average emissions program in the South Coast Nonattainment Area tied to the promulgation of the U.S. EPA National Locomotive Rule. The intent was to accelerate introduction of newer, lower-emitting locomotives in the South Coast. A Memorandum of Understanding (MOU) between ARB and the railroads was signed in July 1998. The MOU includes provisions for early introduction of cleaner locomotives, with requirements for a fleet average in the South Coast equivalent to U.S. EPA's 2005 locomotive standard by 2010. The agreement fulfills the objective of the 1994 SIP measure, M14: National Emission Standards, that assumes that cleaner federally-complying locomotives will be operated in California and the South Coast.

Implementation of the MOU will reduce emissions in the South Coast by 67 percent by 2010.

c. Emission Reduction Research Program

The railroads (with technical guidance and review by ARB) are investing a minimum of five million dollars over three years to test the feasibility of implementing emission reduction technologies on locomotives. The current focus is to develop and test the feasibility of operating a switchyard locomotive using a diesel particulate filter (DPF). ARB expects that this program will lead to significant advancement in the design of DPF technology for all locomotives and thus could enhance the ability of industry to reduce PM emissions. ARB will also work closely with the railroads to conduct research in demonstrating NOx control technology in locomotives.

d. Carl Moyer Program

The Carl Moyer Program is a heavy-duty diesel engine incentive program designed to obtain early emission reductions of NOx and particulate matter from heavy-duty vehicles and equipment, including locomotives. Under the program, ARB has the responsibility to establish program guidelines, oversee the program, and report program benefits. Local air districts implement the program and work with the public and private participants. The program provides grants to pay for the extra cost of replacing existing diesel engines with lower-emission engines, including new cleaner diesels, or engines powered by alternative fuels or electricity. Currently, the Carl Moyer program has funded one locomotive. Substantial emission reductions could be achieved with the funding of additional locomotive projects.

3. Control Strategies for Locomotives

Locomotive emissions in the near- and mid-term in the South Coast have been addressed through the locomotive MOU signed in 1998. Under that MOU, additional approaches used by the railroads to reduce NOx emissions may be used by the railroads to comply with the MOU’s fleet average emission requirement. Because of this, ARB staff is not proposing additional locomotive measures for the South Coast at this time.

However, locomotive activity (and thereby emissions) occurs throughout the State. We will assess the need for additional reductions from locomotives and railyards in other areas of the State in regional SIPs over the next year.

4. Long-Term Advanced Technologies Measures

A number of viable control technologies for locomotives are listed below. In addition, in its proposal for tighter emission standards for new land-based off-road equipment and off-road diesel fuel (Tier 4 diesel proposal), U.S. EPA indicated that it will consider reducing the sulfur level in locomotive fuel to 500 ppm, and also take comments on reducing the diesel sulfur fuel requirement for locomotives down to 15 ppm. U.S. EPA also indicated that it would consider developing lower emission standards for locomotive engines, based on the use of advanced control technologies, for implementation in the post-2010 timeframe. ARB believes it is critical that U.S. EPA require the use of 15 ppm sulfur diesel fuel for locomotive vessels beginning in 2010 rather than the 500 ppm sulfur level proposed. Setting that standard will enable U.S. EPA to require the use of PM and/or NOx aftertreatment on these engines – technologies that U.S. EPA is requiring on nearly all other diesel categories. ARB strongly recommends that U.S. EPA proceed as rapidly as possible to initiate a rulemaking to establish aftertreatment-based emissions standards for locomotive engines. Such standards would help address the projected growth in goods movement via rail.

Fleet Turnover: In the near term, a significant reduction in NOx emissions will occur when existing locomotives operating in the U.S. are remanufactured to meet the Tier 0 standards. This should result in a 30 percent reduction in NOx emissions. When fully phased-in, the new standards will reduce NOx emission by nearly two-thirds, and HC and PM emissions by half. New locomotive engines manufactured to Tier 1 standards (2002-2004) and Tier 2 standards (2005+) will have even lower emissions than the uncontrolled or Tier 0 locomotives in use today. Any mechanism for accelerating fleet turnover could significantly reduce emissions.

Reduced Idling: The railroads are already taking a number of steps to reduce idling. For example, all major railroads currently have a policy to shut down locomotives when they would idle for greater than a specified time (generally 30 minutes to an hour), providing that ambient temperatures are moderate (generally above 40-50 degrees Fahrenheit). Automatic idle limiting devices are available for use on new engines and can be retrofitted to existing engines. ARB will meet with the railroads to investigate how idling emissions can be further reduced at railyards and on sidings, and to enforce existing idling policies.

Retrofits:

Diesel Particulate Filters: The recently adopted U.S. EPA locomotive rule will result in significant reductions in diesel PM emissions from locomotives beginning with model year 2005. The national rule only affects PM emissions from model year 1973 and later locomotives at the time of purchase or remanufacture and does not reduce PM emissions from older locomotives. Control of PM is expected to occur through improvement in air cooling, fuel management, combustion chamber configuration, and electronic controls. At the time of its rulemaking, U.S. EPA did not consider diesel particulate filters a technology that manufacturers would use to meet Tier 2 standards. However, because of recent developments in diesel particulate filter technology, it appears retrofitting locomotive engines with particulate filters would result in significant reductions in diesel PM emissions, especially when coupled with requirements for low sulfur fuel. As mentioned above, ARB is currently working with the railroads to demonstrate the use of a PM filter on a locomotive. The demonstration program is scheduled to be complete in 2004. Some associated HC emission reductions would also be expected due to the particulate filter.

NOx Control Technologies: New methods for reducing NOx emissions may prove feasible as technology advances over time. ARB will review the feasibility of selective catalytic reduction (SCR) as a method to control NOx emissions in the future, as appropriate. Also, NOx adsorber technology is expected to improve in the near term and to be used in on-road vehicles. Depending on durability, space constraints, operational constraints, and cost, this technology may be transferable from on-road vehicles to locomotive applications.

Fuel Changes: Besides the lower sulfur diesel fuel discussed above, currently available alternative fuels and alternative diesel fuel formulations could also be used to reduce NOx, PM and HC from in-use locomotives. Emulsified fuels or other alternative diesel fuels may be a more immediate emission reduction option for earlier model year locomotives, where control retrofit options are very expensive or difficult to implement. These fuels have been formulated for use in existing diesel-powered vehicles and equipment, new and old, without hardware add-ons, engine modifications or replacements. Emulsified or alternative diesel fuels have been shown to reduce NOx and PM emissions by 14 percent and 63 percent, respectively (in on-road heavy-duty diesel vehicles), when compared to ARB diesel. Transferring the use of these fuels to switch-yard and local locomotives could result in emission reductions. The use of emulsified or other alternative diesel fuels may necessitate injector replacement if peak power is to be maintained. However, power limitation in switch-yard locomotives is seldom an issue.

Converting diesel-powered locomotive engines to alternative fuels, such as compressed natural gas (CNG), liquefied natural gas (LNG) and dual fuel, has become a viable technology for reducing NOx and PM emissions from locomotive engines. Alternative fuel technology has been incorporated into several locomotives nationwide. In fact, through the Carl Moyer Program, the Napa Valley Wine Train in California was converted from diesel to CNG. ARB estimates that NOx emissions were reduced about 50 percent from converting this locomotive engine powered by diesel to an engine powered by natural gas.

CHAPTER J

Conventional and Alternative Fuels

CHAPTER J. CONVENTIONAL AND ALTERNATIVE FUELS

1. Category Description

Today, there are 24 million gasoline-powered vehicles registered in California and over a million diesel-fueled vehicles and engines. To power these vehicles, over 14 billion gallons of gasoline and approximately 3 billion gallons of diesel fuel are consumed annually.

Gasoline and diesel motor vehicle fuels emit a variety of pollutants that impact human health. To address these impacts, the California Clean Air Act (CCAA) requires ARB to adopt fuel specifications to reduce exhaust and evaporative emissions from motor vehicles. California Health and Safety Code Section 43018 (a) states, "[t]he state board shall endeavor to achieve the maximum degree of emission reductions possible from vehicular and other mobile sources in order to accomplish the attainment of the state standards at the earliest practicable date."

a. Fuel Characteristics

For most motor vehicle owners in the United States, the most practical fueling options are gasoline for light-duty vehicles and diesel fuel for heavy-duty vehicles. These two fuels are relatively inexpensive, and mature marketing and distribution infrastructure already exists. Diesel fuel is also commonly used in light-duty vehicles in Europe and other parts of the world.

The discussion below summarizes fuel characteristics of the mainstream fuels (gasoline and diesel fuel), as well as alternative fuels (compressed natural gas, liquified natural gas, liquified petroleum gas, methanol, ethanol, hydrogen, and electricity).[1]

Gasoline: Nearly all light-duty vehicles run on gasoline, which is relatively inexpensive and has a mature infrastructure with more than 11,000 fueling stations in California. Over the past century, automotive engineering has developed gasoline engines that perform well. Reformulated gasoline has enabled engines to reduce emissions. However, collectively, automobiles are still a major source of ROG (evaporative emissions from the fuel system, cold starts, running exhaust emissions), NOx, and carbon dioxide (CO2).

Diesel Fuel: Diesel engines are more fuel-efficient than gasoline-powered engines, but due to the higher compression ratios, the engines have to be sturdier. Thus, diesel engines are practical for trucks, buses, other heavy-duty vehicles, locomotives, and ships. Current diesel engines create more PM and NOx, but less CO2

[1] California Energy Commission, "ABCs of AFVs: A Guide to Alternative Fuel Vehicles – Fifth Edition," November 1999.

than gasoline engines. ARB has identified particulate matter from diesel-fueled engines as a toxic air contaminant. Raising the ignition temperature suppresses PM formation, but results in more NOx. Likewise, lowering the ignition temperature suppresses NOx but yields more PM. Evaporative emissions are not a problem for diesel fuel, due to its low vapor pressure. Very low-sulfur fuel, required statewide in 2006, is necessary in order to use diesel particulate filters and NOx converters to reduce emissions.

Compressed/Liquefied Natural Gas: Compressed natural gas (CNG) and liquefied natural gas (LNG) are substitutes for diesel fuel in heavy-duty applications such as transit buses and school buses. Light-duty vehicles can also be powered by CNG in place of gasoline. CNG-powered and LNG-powered engines produce less PM, but about the same amount of NOx as diesel engines. CO2 exhaust emissions are also lower because natural gas gets more of its energy from hydrogen and less from carbon compared to diesel fuel. However, natural gas consists mainly of methane, which is a greenhouse gas. CNG is available at over 100 retail outlets in California, but there are currently few public access LNG stations. LNG has advantages over CNG in heavy-duty vehicles for which range and payload are critical, such as locomotives and trucks over 33,000 pounds.

Liquefied Petroleum Gas: Liquefied petroleum gas (LPG) is a combination of hydrocarbons like propane, ethane and butane. It has less carbon than gasoline, but more carbon than natural gas, so its CO2 emissions are between that of gasoline and natural gas. LPG combustion produces some PM and sulfur emissions, but yields less ROG and NOx emissions than gasoline combustion. However, LPG evaporative emissions can release more ROG than gasoline does. California has over 500 retail outlets that sell LPG.

Methanol: Most methanol is made from natural gas, but biomass can be a renewable source as well. Methanol serves as a substitute for gasoline. Indeed, methanol is the fuel of choice for Indianapolis 500 racing cars. This fuel provides a high octane number and high performance while burning at a cooler temperature, producing fewer CO2 emissions and half as much NOx as gasoline does. Light-duty flexible fuel vehicles use M85 (85 percent methanol, 15 percent gasoline), which is sold at a few locations in California. Methanol costs more than gasoline on an energy-equivalent basis. Heavy-duty vehicles use M100 (methanol without gasoline) and produce less NOx and PM than diesel fuel vehicles. Methanol heavy-duty engines are significantly more expensive than their diesel counterparts. Methanol is a promising fuel for reforming into hydrogen for fuel cells. Work is underway to develop a direct injected methanol fuel cell that requires no reformer.

Ethanol: Corn, grains, and agricultural waste (including rice) products and residues are the sources of ethanol, a renewable fuel. Depending on how it is produced, the use of ethanol can reduce greenhouse gas emissions, compared to the use of gasoline. Ethanol flexible-fuel vehicles use E85 (85 percent ethanol, 15 percent gasoline), which is not available to the public in California. Ethanol has a lower energy content than gasoline and relies on tax incentives to make the fuel cost per mile similar to gasoline. In California, ethanol has more potential as an additive to gasoline (to replace the oxidant methyl tertiary butyl ether (MTBE)) than as a fuel in its own right.

Hydrogen: Water is the only by-product of fuel cells powered by hydrogen. This clean fuel produces no greenhouse gas emissions nor pollutants. The challenges involve producing and distributing hydrogen. Currently, most hydrogen comes from natural gas (thus, emitting some greenhouse gases), but electrolysis powered by wind power or solar energy is a future possibility. Hydrogen gas is awkward to handle -- its volumetric energy density is low, and it costs more than diesel fuel on a per mile basis. In the foreseeable future, hydrogen will be practical for centrally-fueled fleets of large vehicles with space for hydrogen storage, such as transit buses.

Electricity: Battery-powered cars are the original zero emission vehicles. The power plant releases lower CO2 and lower pollutant emissions in recharging the battery, compared to burning gasoline in the car. Drawbacks include limited range, long recharging time and bulky or expensive battery packs. Drivers in California can recharge at home or at hundreds of public charging stations through the State. Auto manufacturers are focusing on neighborhood electric vehicles as suitable niches for battery-powered electric vehicles.

California's zero emission vehicle program is essential to attaining State ambient air quality standards as well as achieving significant improvements in total environmental impact of transportation in the light-duty vehicle sector. Beyond the benefits of reduced criteria pollutants, zero emission vehicles have reduced total fuel cycle and reduced emissions of toxic air contaminants and impacts on other environmental media.

The success of the zero emission vehicle program depends on the State's support of innovative technology changes in the automotive industry as well as in the infrastructure used to support it. Electric vehicles have been successfully demonstrated as practical, reliable zero emission vehicles. Fuel cells, using stored hydrogen, provide a longer-term option for widespread implementation of zero emission vehicles. Research and development in fuel cell vehicle technology is moving quickly toward commercialization. Deployment of electric recharging and hydrogen refueling infrastructure will greatly improve the commercial market potential, acceptance, and fleet penetration of zero emission vehicles.

The ultimate goal will not only be widespread implementation of zero emission vehicles and infrastructure, but also zero upstream fueling emissions. Air quality impacts of transportation range from the extraction of fuel/energy through refining, delivery and refueling, to finally the direct vehicle emissions. In addition to benefits of no direct vehicle emissions, electric and fuel cell vehicles using electricity or stored hydrogen have the potential to be nearly emission free from "well to wheel." By using electricity or hydrogen generated from renewable energy such as solar or wind, an electric or fuel cell vehicle could have zero impact on air quality. Given growing demand for petroleum and the impacts of using carbon-based fuels on the environment in the conversion of that energy to motive power, pursuit of electricity and hydrogen, derived from renewable sources is a great opportunity to move into a truly zero emission future.

b. Pollutants/Toxic Compounds

The use of fuels such as gasoline, diesel, and alternative fuels in motor vehicles results in the emissions of many different pollutants. Exhaust emissions occur due to both the incomplete combustion of fuel as well as the formation of other compounds due to the heat of combustion. Pollutants in motor vehicle exhaust include CO, NOx, SOx, and toxic compounds such as benzene, 1,3-butadiene, aldehydes (such as formaldehyde), polycyclic aromatic hydrocarbons (PAHs), and PM (including diesel PM).

Evaporative emissions, which are mostly ROG, result from fuel escaping from the fuel system. Sources of evaporative emissions from motor vehicles include fuel tanks and fuel lines. As temperatures increase within the fuel system, increased evaporation occurs, resulting in greater emissions. Many of the ROGs that evaporate are also toxic air contaminants, including benzene, toluene, and PAHs.

2. Existing Control Program

As shown in Table II-J-1, ARB has implemented a number of fuels programs that have provided significant reductions in vehicular emissions. These programs have contributed significantly to the air quality gains that have been achieved over the past 20 years and are a major component in ARB's efforts to achieve both the federal and State air quality standards statewide.

Table II-J-1
Summary of Fuels Program Benefits
(Statewide, tpd)

Program	Emissions Reductions (tpd)					
	ROG	NOx	PM	SOx	CO	Toxics
Diesel (1993)	17	70	20	80	--	25%
Phase I Reformulated Gasoline (1992)	210	--	--	--	--	--
Winter Oxygenate	20	--	--	--	1200	--
Phase II Reformulated Gasoline (1996)	190	110	--	30	1300	30%
Phase III Reformulated Gasoline (2003)	0.5	19	--	4	--	7%

Note: Emission benefits shown on this table are not additive as they are based on different calendar years and baseline inventories.

A brief summary of the steps ARB has taken to reduce fuel-related emissions is provided below.

Reformulated Gasoline

Reformulated gasoline remains one of the cornerstones of California's effort to achieve healthful air quality. Reformulated gasoline reduces emissions from older vehicles while enabling emission-control systems in late model vehicles to work at high efficiencies. New vehicles are as much as 85 percent cleaner than automobiles produced in the early 1990s. Without reformulated gasoline, these vehicles cannot operate at the emissions levels for which they were designed. Highlights from ARB's Cleaner Burning Gasoline Program are listed below.

a. Phase I Cleaner Burning Gasoline

In 1990, ARB adopted the California Phase I reformulated gasoline regulations that included a new Reid vapor pressure (RVP) limit, requirements for deposit control additives, and the elimination of lead from gasoline starting in 1992. These regulations resulted in ROG emission reductions of 210 tpd.

b. Wintertime Oxygenate Program

As required under the federal Clean Air Act, ARB adopted a regulation in 1991 requiring gasoline sold in California to contain an oxygen content of 1.8-2.2 percent during winter months to help areas with poor CO air quality meet the standards. The program reduced wintertime motor vehicle CO emissions by 10 percent (about 1200 tpd) and ROG emissions by about 20 tpd in 1992-93, when the oxygenate requirement went into effect. Most of California now meets the federal CO air quality standards with the exception of Calexico in Imperial County. ARB rescinded the wintertime oxygen requirement in 1998 for areas where the requirement is no longer needed to achieve and maintain the CO air quality standard. Rescinding the wintertime oxygen requirement provides refiners additional flexibility and assists in the phase-out of MTBE.

c. Phase II Cleaner Burning Gasoline

In 1991, ARB adopted the California Phase II reformulated gasoline (CaRFG2) regulations which contained a comprehensive set of specifications for eight fuel properties designed to achieve the maximum reductions in ROG, NOx, SOx, PM, CO, and toxic air emissions starting in 1996. The regulations sought to provide flexibility to refiners to produce the cleanest possible gasoline at the lowest cost to the consumer by providing compliance options to gasoline producers. CaRFG2 reduced smog-forming emissions from motor vehicles by 15 percent (equivalent to removing 3.5 million vehicles from California roads) and reduced toxic air emissions from gasoline use by 40 percent.

d. Phase III Cleaner Burning Gasoline

In 1999, ARB adopted the Phase III cleaner burning gasoline regulations to enable refiners to produce MTBE-free gasoline while preserving the air quality benefits of existing gasoline. The regulations prohibit the addition of MTBE to California gasoline after 2002 and reduce the sulfur and benzene content of gasoline. The action implements the provisions of Governor Gray Davis' Executive Order calling for the phase out of MTBE from gasoline. The Governor issued the Executive Order after determining there is significant risk to the environment from using MTBE in gasoline in California, because MTBE from leaking underground fuel tanks threatens groundwater and drinking water quality.

Diesel Fuel

In 1988, ARB approved new specifications for California diesel fuel. These regulations, implemented in 1993, established limits on both the sulfur (500 parts per million by weight) and aromatic hydrocarbon content (10 percent by volume, and 20 percent for small refiners). The regulations reduced SOx emissions by 80 tpd (with concurrent sulfate particulate reductions), NOx emissions by 70 tpd, PM emissions by 20 tpd, and ROG emissions by 17 tpd in 1993. The regulation reduced toxic emissions as well.

Recently, U.S. EPA adopted national diesel fuel standards that will lower sulfur content to 15 ppm starting in 2006. This change enables tighter emission standards for new diesel engines and retrofits that require the use of NOx adsorbers and particulate filters. As described in the description for measure FUEL-2, in July 2003, ARB staff proposed, and the Board approved, incorporating the new sulfur limits into the California diesel fuel regulations.

Alternative Fuels

While not used in the same quantities as gasoline and diesel fuel, alternative fuels play an important part in California's transportation and clean air strategies. In 1990, ARB established specifications, effective in 1993, for the following seven alternative fuels to ensure the availability of consistent fuel-quality alternatives while providing the expected benefits from the low-emission vehicle/clean fuels program:

- M-100 fuel which contains 100 percent methanol
- M-85 fuel which contains 85 percent methanol and 15 percent gasoline
- E-100 fuel which contains 100 percent ethanol
- E-85 fuel which contains 85 percent ethanol and 15 percent gasoline
- Compressed natural gas (CNG) which contains 88 percent methane
- Liquefied petroleum gas (LPG) which contains 85 percent propane,
- Hydrogen.

Also in 1990, ARB adopted a regulation designed to ensure that clean alternative fuels are available to meet public demand. The regulations require certain retail gasoline station owners to equip an appropriate number of their stations to dispense a designated alternative fuel if at least 20,000 vehicles are certified in California to a low-emission vehicle (LEV) standard on the fuel. To date, the 20,000 vehicle trigger has not been met for any fuel.

In order to reduce emissions from motor vehicles, ARB has launched several programs and regulations that are summarized in the subsequent paragraphs. These ongoing programs augment the introduction of vehicles powered by alternative fuels, such as CNG, LNG, LPG, by offering funds for the incremental cost of the lower emission equipment.

The Carl Moyer Program: The Carol Moyer program is a heavy-duty diesel engine incentive program designed to obtain early emission benefits from a wide variety of heavy-duty vehicles and equipment such as trucks, buses, locomotives, boats, and agriculture and construction equipment. The Carl Moyer program funds the incremental cost of cleaner alternative-fueled vehicles. Since its inception in 1998, the program has funded $44.5 million in alternative fuel and electric projects. A portion of these funds went to the California Energy Commission to expedite the research and development of additional technologies to achieve emission reductions.

Public Transit Bus Fleet Rule: The Public Transit Bus Fleet Rule was established to promote the use of alternative-fueled buses for transit agencies. The fleet rule also requires the larger transit agencies to demonstrate the highly advanced zero emission buses with purchase requirements starting in 2008.

Lower Emission School Bus Program: Another incentive program to reduce school children's exposure to particulate and smog-forming pollutants is the Lower-Emission School Bus Program. In the 2000-2001 fiscal year, $50 million has been apportioned for the purchase of 350 new school buses powered by diesel and alternative fuels besides retrofitting the existing school buses with catalyzed diesel particulate filters. For the fiscal year 2001-2002, $16 million will go towards the purchase of 110 new school buses and for the retrofit of about 640 older school buses.

Zero Emission Vehicle Support

The zero emission vehicle program was first adopted in 1990 as part of the low-emission vehicle regulations. Zero emission vehicle (ZEV) regulations have been modified over the last 10 years; however, the core requirement remains and contains the flexibility necessary to encourage the development of a variety of near-zero and zero emission technologies.

In 2001, ARB adopted modifications to the ZEV regulation to establish standards for electric vehicle charging. The Board decided this standardization regulation was necessary to support electric vehicle deployment as the market was on a divergent path. There were at least three commonly used charger types. Standardization provides market certainty, reduces cost to public infrastructure providers and encourages focused technology and cost improvements in a single technology. The Board has not taken any regulatory action to support or standardize hydrogen-fueling infrastructure. At this early stage in development, significant divergence in vehicle to fueling equipment technology has not surfaced. Research and development activities into the best method for hydrogen storage and fueling is ongoing. ARB staff is encouraged by the early willingness of vehicle manufacturers to work together with fuel providers to explore standards for hydrogen use.

ARB is working with the State and local governments to develop ZEV infrastructure and remove barriers to ZEV introduction. For example, an increasing percentage of light-duty vehicles manufactured must be ZEVs. The ZEV Incentive Program (ZIP) grants up to $5,000 per ZEV so that consumers could buy the electric vehicle at a price comparable to the conventional vehicles. Additionally, ARB participates in the Fuel Cell Partnership – a partnership of industry and government designed to facilitate the development and commercialization of fuel cell-powered vehicles.

3. Proposed Strategies

There are two strategies identified for this category that are summarized in Table II-J-2 below and further described in this section.

Strategies	Timeframe	
	Action	**Implementation**
FUEL-1: Set Additives Standards for Diesel Fuel to Control Engine Deposits	2006 – 2009	2006 - 2010
FUEL-2: Set Low-Sulfur Standards for Diesel Fuel for Trucks/Buses, Off-Road Equipment, and Stationary Engines	2003	2006

a. FUEL-1: Set Additives Standards for Diesel Fuel to Control Engine Deposits

Time Frame: Adopt 2006-2009; Implement 2006-2010

Responsible Agency: ARB

Proposed Strategy:

Diesel engines, like spark-ignited engines, develop engine deposits over time. Deposits are formed on the injectors and in the combustion chamber. Deposits on the injectors develop from the formation of gums and resins that act as binders for minute particles in the combustion gas. These deposits interfere with the injector spray pattern, which in turn may affect proper combustion. Engine deposits that form in the combustion chamber may also adversely affect combustion. Both injector deposits and combustion chamber deposits could result in increased emissions, decreased power, and decreased fuel economy.

ARB staff will investigate the significance of diesel fuel system and engine deposits and the effect on emissions. Staff will also investigate the effectiveness of deposit control additives to prevent or reduce deposits and their cost. When regulatory action is deemed appropriate, a certification test procedure and an additive performance standard will be developed.

Currently, diesel fuels are regulated for sulfur and aromatics content. There are no regulations requiring the use of deposit control additives for diesel fuel. In 1990, regulations were adopted requiring the use of deposit control additives in California gasoline where they have been shown to clean and maintain port fuel injectors and intake valves. Like gasoline deposit control additives, diesel deposit control additives could be effective in reducing diesel engine deposits and emissions. The proposed method of control is to require the use of deposit control additives in diesel fuel. The fuel would be certified upon passing engine tests that demonstrate that the fuel keeps injectors, cylinders, valves, and other engine parts free of combustion deposits.

Projected emission reductions are not quantifiable at this time. The cleanup and maintenance of diesel fuel systems and engine deposits return engines closer to factory tolerances, which may minimize the deterioration rate of engine-out emissions. This may have an emissions benefit.

SIP Commitment for Measure FUEL-1

South Coast 2003 SIP Commitment:

ARB staff proposes to commit to bring this measure to the Board between 2006 and 2009. We have not quantified benefits for this measure.

Commitments for Future SIPs:

As other areas of the State develop attainment SIPs that require additional emission reductions to show progress and/or attainment, we will work with the appropriate local air districts to determine which State and/or federal measures are appropriate to include for federal approval.

b. FUEL-2: Set Low-Sulfur Standards for Diesel Fuel for Trucks/Buses, Off-Road Equipment, and Stationary Engines

Time Frame: Adopt 2003; Implement 2006

Responsible Agency: ARB

Regulatory History:

Since 1993, ARB's diesel fuel regulations have specified a 500 ppm by weight limit for sulfur and an aromatic hydrocarbon content limit of 10 percent for large refiners and 20 percent for small refiners. Use of diesel fuel meeting California regulations is not required for stationary engines, locomotives, and marine vessels; they are exempt from these regulations. About 90 percent of the diesel fuel sold or supplied in California meets the requirements of the California diesel fuel regulations.

In December 2000, U.S. EPA signed a national diesel fuel rule that will lower sulfur content nationwide to 15 ppm starting in 2006. These standards apply to fuel for on-road vehicles only. The U.S. EPA has also proposed that beginning June 2007, sulfur levels for nonroad diesel fuel be reduced from current uncontrolled levels to an interim limit of 500 ppm, and then in 2010 to the 15 ppm on-road diesel limit. The U.S. EPA is also asking for comment on reducing sulfur levels for locomotive and marine fuel to 15 ppm in 2010.

The South Coast Air Quality Management District has adopted Rule 431.2 that limits the sulfur content of diesel fuel for stationary and mobile sources in the South Coast Air Basin to 500 ppm, but this limit will be lowered to 15 ppm in 2004 for stationary engines and in 2005 for all diesel fuel sold for use in the District. Rule 431.2 allows for an extension of this date to match the ARB's effective date, but no later than June 1, 2006.

Strategy:

In July 2003, ARB staff proposed low-sulfur diesel fuel regulations that reduce statewide the maximum sulfur content allowed in diesel fuel from the current limit of 500 ppm to 15 ppm by 2006. The Board approved the regulation, which applies to diesel fuel produced for on-road and off-road vehicles. The Board also approved an air toxics control measure that would require the use of vehicular diesel fuel in all nonvehicular diesel engines except engines used to power locomotives and marine vessels.

Low-sulfur diesel fuel enables technologies such as catalyzed diesel particulate filters and NOx adsorbers to be used. Heavy-duty diesel vehicles will be able to meet the very low 2007 emission standards with low-sulfur diesel fuel. Low-sulfur diesel fuel will also enable the diesel PM emissions control systems proposed in ARB's Diesel Risk Reduction Plan.

As noted earlier, U.S. EPA has adopted national on-road diesel fuel standards that will lower sulfur content nationwide to 15 ppm starting in 2006. ARB staff is continuing to evaluate what differences would exist between California and federal diesel fuel once the low-sulfur standard is in effect. The goal is harmonization of U.S. EPA's and California's diesel fuel standards while maintaining emission benefits that are comparable to those provided by California diesel requirements.

Diesel fuel used in marine vessels and locomotives is exempted from the ARB and SCAQMD diesel fuel regulations. As stated earlier, the U.S. EPA is requesting comments on a proposal to reduce the sulfur levels for locomotive and marine fuel to 15 ppm in 2010. The Board, in approving the ARB's diesel fuel regulations, also directed the staff to report back to the Board on the sulfur content of diesel fuel supplied to locomotives and marine vessels in the State. The Board also directed the staff to evaluate the appropriateness and feasibility of imposing a 15 ppm sulfur content standard on diesel fuel supplied to locomotives and marine vessels.

Emission Reductions:

Use of low-sulfur diesel fuel reduces PM and SOx emissions and enables the use of aftertreatment technologies which can reduce NOx, PM, and ROG. Because a national on-road diesel fuel rule was already set to go into effect in 2006, the emission benefits for on-road vehicles are already reflected in the baseline SIP emission inventory. The SOx emission benefits from low-sulfur diesel for off-road engines have also been incorporated into the baseline SIP emission inventory because the South Coast Air District had adopted a rule that would apply in lieu of a statewide rule. The PM benefits for off-road engines have not been quantified at this time.

SIP Commitment for Measure FUEL-2

In July 2003, ARB approved regulatory changes to require low-sulfur diesel fuel in all on-road applications and most off-road applications. There is no additional SIP commitment for this measure.

4. Long-Term Advanced Technologies Strategies

Set Sulfur/Ash Content Limits for Diesel Engine Lubricating Oils: This idea would look at the effect on diesel after-treatment technology from limits on sulfur concentration and/or ash content in diesel engine lubricating oil.

In addition to diesel fuel, engine lubricating oil is a source of sulfur and other constituents potentially harmful to after-treatment control technologies essential to achieving emission reductions. Diesel engines are designed to consume some amounts of engine lubricating oils that are burned along with the fuel. Depending on the amount of oil consumed and the level of sulfur and other constituents, the oil consumed can adversely affect the after-treatment controls. Also, lubricating oils can contribute to increased engine-out emissions of sulfur. The significance of engine lubricating oils' contribution to engine-out emissions is not known, but current research efforts are investigating this concern.

If the current research efforts indicate that regulatory action is appropriate, then the concentration of sulfur and/or ash content of diesel engine lubricating oils could be limited for both on-road and off-road vehicles. This would minimize emissions increases by curtailing deterioration rates of the control technology.

Support Infrastructure for Zero Emission Vehicles – Electric and Hydrogen: The main focus of this concept would be to facilitate development of the infrastructure needed to support the current zero emission vehicle regulations and the resulting vehicles that will be introduced to the market. Such efforts would include an examination of the suitability of regulatory standards, research funding priorities, public education efforts and resource allocations. These efforts could also provide support for future mobile and stationary regulatory efforts utilizing zero emission technology.

One potential mechanism would be to build on ARB's existing Clean Fuels Regulation that requires alternative fuels to be made available for sale to the public at high volume service stations once the number of vehicles certified on that fuel exceeds a specified threshold. This provision was originally established in 1990 to ensure fuel infrastructure and supply for the alternative fuel vehicles that were anticipated under the Low-Emission Vehicle program.

Near-Term Electric Vehicle Infrastructure Support:

- Continue installations of electric vehicle public charging stations.
- Pilot programs to establish a self-sustaining network of public charging stations that addresses maintenance, repair, and the cost of electricity, possibly through an electric vehicle driver subscription service.

- Transition to conductive electric vehicle infrastructure by working with infrastructure providers, vehicle manufacturers and electric vehicle drivers to ensure a smooth transition to the standard technology.

Near and Mid-Term Hydrogen Vehicle Infrastructure Support:

- Demonstration projects (fuel cell and hydrogen internal combustion engines) using hydrogen by funding technology development for low cost, semi-permanent, transportable hydrogen stations.
- Encourage hydrogen-fueled technology in regulatory development through setting of standards and demonstration or pilot components.
- Studies to determine the necessary backbone and network of hydrogen stations needed to support early commercialization of hydrogen fueled vehicles.
- Development of appropriate building codes and permitting policies for hydrogen vehicle storage and refueling as well as dissemination of information to building code officials and permitting authorities regarding hydrogen infrastructure.
- National efforts to develop and disseminate a hydrogen education program.
- Standards-setting efforts by the Society of Automotive Engineers and international standards-setting organizations for the fueling of hydrogen vehicles and hydrogen vehicle storage.

Long-Term Hydrogen Vehicle Infrastructure Support:

To carry out any measures as described above would require financial support of the State. Such support would be in the form of research funding, staffing and demonstration/pilot project funding. The implementation period for the activities described above should take place over the next five to ten years.

a. Federal Responsibility

U.S. EPA has not yet set low-sulfur diesel fuel requirements for off-road engines. U.S. EPA has proposed to required 15 ppm sulfur diesel fuel for land-based off-road engines nationally by 2010 and sought comment on extending the requirement to locomotives and marine vessels. Broad national standards for 15 ppm sulfur diesel fuel should apply to every type of off-road diesel engine by 2010 or earlier. This would cut emissions directly and enable advanced control technology on both new and existing diesel engines in all applications.