California Environmental Protection Agency
AIR RESOURCES BOARD

TECHNICAL SUPPORT DOCUMENT: PROPOSED REGULATION FOR IN-USE OFF-ROAD DIESEL VEHICLES

Mobile Source Control Division
Heavy Duty Diesel In-Use Strategies Branch

April 2007

State of California
AIR RESOURCES BOARD

TECHNICAL SUPPORT DOCUMENT:
REGULATION FOR IN-USE OFF-ROAD DIESEL VEHICLES

Public Hearing to Consider

ADOPTION OF THE PROPOSED REGULATION FOR
IN-USE OFF-ROAD DIESEL VEHICLES

To be considered by the Air Resources Board at a two-day meeting of the Board that will commence on May 24, 2007, and may continue to May 25, 2007, at

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State of California
AIR RESOURCES BOARD

PROPOSED REGULATION FOR IN-USE OFF-ROAD VEHICLES

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I. OVERVIEW AND RECOMMENDATION

A. Introduction

The California Air Resources Board's (ARB or Board) mission is to protect public health, welfare, and ecological resources through the effective and efficient reduction of air pollutants, while recognizing and considering the effects on the economy of the State (ARB, 2002). ARB's vision is that all individuals in California, especially children and the elderly, can live, work, and play in a healthful environment – free from harmful exposure to air pollution. To implement this, ARB has adopted numerous regulations to control emission from many different sources, including diesel engines. This is because diesel engine exhaust is a source of unhealthful air pollutants including gaseous- and particulate-phase toxic air contaminants (TAC), particulate matter, oxides of nitrogen, carbon monoxide, and hydrocarbons.

Staff are proposing a regulation to reduce emissions from in-use off-road diesel vehicles. Such vehicles include construction equipment like scrapers, graders, backhoes, as well as other mobile diesel vehicles such as forklifts and airport ground support equipment.

This technical support document is an addendum to the Initial Statement of Reasons and includes the following chapters:

- Background information, the purpose of the regulation (Chapter 1)
- ARB's legal authority to adopt the regulation (Chapter 2);
- Summary of the extensive public outreach conducted to solicit public input on the proposed regulation (Chapter 3);
- Discussion of the need for control of diesel particulate matter from in-use off-road diesel vehicles (Chapter 4);
- Discussion of the various types of off-road vehicles, what they are used for, the industries in which they are used, and the emission standards to which new off-road engines are subject (Chapter 5);
- Emissions, population, vehicle ages, and engine tier distribution of in-use off-road diesel vehicles (Chapter 6);
- Summary and discussion of the proposed regulation (Chapter 7);
- Technological feasibility of the proposed regulation, including retrofits, repowers, and accelerated turnover of vehicles (Chapter 8);
- Environmental impact and cost-effectiveness of the proposed regulation (Chapter 9);
- Alternatives considered (Chapter 10);
- Economic impacts of the proposed regulation (Chapter 11);
- Discussion of regulation development topics such as incentive funding and enforceability (Chapter 12); and
- Proposed text of the measure and other supplementary information (Appendices).

B. Overview

Staff of the Air Resources Board (ARB or Board) is proposing a regulation that would reduce emissions of diesel particulate matter (PM) and oxides of nitrogen (NOx) from nearly 180,000 off-road diesel vehicles in the State. The regulation would achieve these emission reductions by requiring fleet owners to modernize their fleets and install exhaust retrofits. The regulation is projected to achieve significant emission reductions, but at a significant cost to affected fleets.

The scope of the regulation is far-reaching; vehicles of dozens of types used in over 8,000 fleets, in industries as diverse as construction, air travel, manufacturing, landscaping, and ski resorts, as well as by a considerable number of public agencies, would be affected. The regulation would affect the warehouse with one diesel forklift, the landscaper with a fleet of a dozen diesel mowers, the county that maintains rural roads, the landfill with a fleet of dozers, as well as the large construction firm or government fleet with hundreds of diesel loaders, graders, scrapers, and rollers.

The regulation, a copy of which is provided in Appendix A, would mean different things for different fleets, depending on their size and on the vintage of their vehicles. Fleets are defined in the regulation as small, medium, or large based on their total horsepower and whether they are a small business. The regulation has the strictest provisions for the largest fleets, which have the most significant emissions and which are most likely able to rapidly understand and absorb the costs of regulation compliance. The regulation has the least stringent provisions for the smallest fleets owned by small businesses or municipalities.

The regulation would establish fleet average emission rate targets for PM and NOx for all off-road vehicles operating in the state, regardless of whether they are California based or not. The targets decline over time, requiring fleets to reduce their emissions further as time goes on. Each year, the regulation requires each fleet to meet the fleet average emission rate targets for PM or apply the highest level verified diesel emission control system to 20 percent of its horsepower. Each year, the regulation also requires large and medium fleets to meet the fleet average emission rate targets for NOx or to turn over a certain percent of their horsepower (8 percent in early years, and 10 percent in later years). Turn over means repowering with a cleaner engine, retiring a vehicle, replacing a vehicle with a new or used piece, or designating a dirty vehicle as a low-use vehicle. If retrofits that reduce NOx emissions become available, they may be used in lieu of turnover as long as they achieve the same emission benefits.

Each year, fleets would have the option of satisfying either the fleet average requirements or the mandatory retrofit and/or turnover requirements. To meet the fleet averages, fleets may retrofit their vehicles' exhaust systems with verified diesel emission control devices, replace the engines in existing vehicles with cleaner engines (i.e., repower), retire high-emitting vehicles, and/or designate high-emitting vehicles as low-use vehicles. The regulation would also limit unnecessary idling to 5 minutes.

Small fleets would be subject only to the PM requirements beginning in 2015. Small fleets that do not meet the PM fleet average targets would need to install exhaust retrofits on 20 percent of their horsepower per year beginning in 2014. Small fleets with newer vehicles may choose to either voluntarily accelerate turnover of their fleets enough to meet the PM fleet average targets or to apply some exhaust retrofits.

Medium fleets would be subject to the PM and NOx requirements beginning in 2013. Medium fleets with the oldest vehicles would not be able to meet the fleet average targets and would need to accelerate turnover of engines to 8 percent of their horsepower per year and install exhaust retrofits on 20 percent of their horsepower per year beginning in 2012. Medium fleets with newer vehicles would not have to do the maximum turnover or maximum exhaust retrofit installations but may have to accelerate the purchase of some vehicles and install enough exhaust retrofits to meet the average targets.

Large fleets would be subject to the PM and NOx requirements beginning in 2010. Large fleets with the oldest vehicles would need to accelerate turnover of engines to 8 percent of their horsepower per year and install exhaust retrofits on 20 percent of their horsepower per year beginning in 2009. In 2015, the oldest large and medium fleets would need to further accelerate turnover to 10 percent of their horsepower per year. While the regulation provides time for retrofit vehicles to remain in the fleet, these oldest fleets may also need to turn over some of the oldest engines that are retrofit once the exhaust retrofits are older than 6 years. Large fleets with newer vehicles would need to accelerate turnover of their fleets enough to meet the NOx fleet average targets and to apply enough exhaust retrofits to meet the PM fleet average targets.

The regulation is expected to reduce 48 tons per day (tpd) NOx and 5.2 tpd of PM statewide in 2020. These reductions represent a 32 percent reduction in NOx and a 74 percent reduction in PM from the 2020 emissions that would otherwise occur in the absence of the regulation.

The regulation would also contribute to achieving the 2020 goal set forth in the 2000 Diesel Risk Reduction Plan of reducing diesel PM 85 percent from all diesel sources from 2000 baseline levels. The regulation is projected to reduce PM emissions 37 percent from the 2000 baseline by 2010, and 92 percent by 2020 from the sources subject to this regulation.

The emission reductions from the regulation would be expected to prevent approximately 4,000 premature deaths (1,100 to 6,800, 95% confidence interval) and tens of thousands of cases of asthma-related and other lower respiratory symptoms, and provide a benefit of $18 to $26 billion in avoided premature death and health costs.

The regulation is the next in a series of rules intended to reduce emissions from in-use diesel vehicles and equipment. However, the scope of the regulation dwarfs previous air toxic control measures that the Board has approved. By comparison, the cargo handling air toxic control measure (ATCM) affects about 3,700 pieces of cargo handling equipment; the solid waste collection vehicle rule affects about 12,000 solid waste collection vehicles; and the portable engine ATCM covers about 33,000 portable engines (ARB, 2005a; ARB, 2006; ARB, 2004). Likewise, the benefits of the proposed regulation are dozens of times larger than those of previous measures. In total, the proposed regulation is expected to reduce 187,000 tons of NOx emissions and 33,000 tons of PM emissions between 2009 and 2030.

The regulation would provide greatly needed reductions of NOx emissions in the South Coast and San Joaquin Valley air basins. These areas must achieve significant NOx reductions from the off-road sector to achieve ambient ozone and fine particulate matter (PM2.5) standards by the federally-mandated deadlines. The deadline for the attainment of the PM2.5 standards in these regions is currently 2015, so emission reductions are urgently needed. Staff expects that despite a comprehensive effort to meet the PM2.5 standard, California may still come up short in achieving the needed emission reductions by the 2015 federal attainment deadline. Because the standard is an annual average, the U.S. EPA requires that all necessary emission reductions be achieved one calendar year sooner, or by 2014. While all sources of NOx emissions are important, off-road diesel vehicles are one of four major categories that will determine whether California is able to meet the 2014 deadline for PM2.5 attainment in the South Coast Air Basin. If the emissions reductions needed to achieve attainment of the federal standards cannot be demonstrated, the Board may need to consider additional measures or changes. However, staff believes the proposed regulation represents the economic limit of what industry could bear, and any further emissions reduction requirements would likely require financial incentives.

The regulation is controversial among the fleets it would impact in large part because it would impose significant costs on industry. The total cost of the regulation is expected to be between $3.0 and $3.4 billion in 2006 expenditure equivalent dollars (2006 dollars). This cost would be spread over the years 2009 to 2030, with the majority of costs occurring between 2010 and 2021. On average over the course of the regulation, the cost would vary between $229 million and $257 million per year, averaging $243 million per year (2006 dollars). About half the cost is expected to be incurred directly by the construction industry, nearly 15 percent by the business services sector, and about 10 percent by the mining industry. Government fleets are expected to incur about 5 percent of the total cost, with the remaining costs spread among various other affected industries.

Costs to individual fleets would vary depending on the size of each fleet, its initial vehicle composition and vehicle age, and its normal purchasing practices. Costs also would vary depending on the compliance strategy chosen by each fleet (retrofit, repower, buy new, and/or buy used). For a typical fleet, total costs over the life of the regulation are expected to be $104 to $117 per horsepower of affected vehicles (in 2006 dollars). Individual fleets may incur average costs anywhere from $0 to about $170 per horsepower (hp), depending on their initial composition and vehicle age. There may be cases where fleets could incur slightly higher costs. Annual costs for a typical fleet would range from $8 to $9 per horsepower per year (2006 dollars). For a typical medium sized fleet with total fleet horsepower of 3,000, the total cost of the regulation is expected to be about $333,000 (in 2006 dollars), with average annual costs of $27,000 per year (in 2006 dollars) for 21 years.

Overall, most affected businesses could absorb the costs of the proposed regulation with no significant adverse impacts on their profitability. Manufacturing business are the least likely to be able to pass on their cost if the product they manufacture is sold nationally or globally, but the economic impact of the regulation is not expected to be a significant part of normal operating expenses. However, most construction fleets, rental companies, airlines, and landscaping service fleets who compete locally should be able to pass on some or all of the costs of compliance to their customers, thereby maintaining their profitability. Even if fleets were unable to pass on any of the cost of compliance to their customers, staff found that between about 60 and 80 percent of fleets would still be expected to be able to withstand the cost of the regulation without incurring more than a 10 percent change in their return on equity. Small fleets would be more likely to be able to absorb the cost of the regulation without exceeding 10 percent change in “return on owner’s equity” (ROE) because they are not subject to the regulation’s mandatory turnover provisions, and thereby would incur significantly less costs relative to medium and large fleets. The 20 to 40 percent of fleets for which the regulatory costs exceed a 10 percent change in ROE would have to pass through at least some of the costs to their customers to maintain their profitability.

The regulation is expected to raise the cost of construction in California by no more than 0.3 percent as fleets pass on the cost of compliance to their customers. Customers that could expect to pay higher construction costs include developers, home builders, and government agencies sponsoring road construction and other transportation projects. For the average new home buyer, the expected cost of the regulation could add about $5 per month to a 30-year mortgage.

The regulation would require fleets to change their operating and vehicle purchasing practices. For the first time, owners of off-road vehicles would need to label them and report them to the State. The regulation would require upgrades with newer engines or turnover of vehicles that fleets purchased years ago, and which they had assumed could be used indefinitely. The regulation would require use of retrofit devices that, while verified by the ARB, are unfamiliar to fleets.

The regulation contains flexibility provisions to allow each fleet to find its own most cost-effective way to comply. The regulation would allow fleets to comply by meeting a fleet average so each fleet can choose its own best, most cost-effective path toward compliance. The regulation contains special exemptions for low-use vehicles, specialty vehicles, emergency vehicles, and dedicated snow removal vehicles. The regulation contains provisions that would give fleets more time if they encounter delays in obtaining the engines, vehicles, or retrofits that they need to comply. Finally, the regulation gives the smallest fleets more time to comply, leaving them several years to apply for State incentive funding.

Staff has made an enormous effort to notify affected fleets and interested parties about the proposed regulation, and to solicit their input on the regulation. The latest seven workshops held across the state since December 2006 were attended by over 1,500 people. These workshops capped a two-year long outreach and regulation development process that included 19 public workshops and workgroup meetings, dozens of site visits and private meetings with fleet owners, equipment dealers, and industry groups, and multiple mailings to over 300,000 contractors, landfills, owners of portable equipment, and numerous other potential owners of affected off-road vehicles.

C. Recommendation

Staff recommends the Board adopt a new section 2449 entitled "Emission Standards for In-Use Off-Road Diesel-Fueled Fleets" in its entirety in California Code of Regulations, title 13, division 3, chapter 9, in a new Article 4.8 entitled "In-Use Off-road Diesel-Fueled Fleets". The regulation is set forth in the proposed regulation order in Appendix A.

D. References

ARB, 2002. California Air Resources Board. California Air Resources Board Strategic Plan. January 2002. http://www.arb.ca.gov/planning/plan01/plan01.htm

ARB, 2004. California Air Resources Board. *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Airborne Toxic Control Measure for Diesel-Fueled Portable Engines*. January 2004.

ARB, 2005a. California Air Resources Board. *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Regulation for Mobile Cargo Handling Equipment at Ports and Intermodal Rail Yards*. October 2005

ARB, 2006. California Air Resources Board. First Annual Update Solid Waste Collection Vehicle Status of Implementation. June 2006.

II. REGULATORY AUTHORITY

ARB has authority under federal and California law to adopt the proposed regulation. Indeed, ARB is mandated by the California law to adopt vehicular airborne toxic control measures for identified air toxic contaminants (TACs), including diesel PM (HSC § 39667)[1]. ARB is further directly authorized to adopt emission standards for off-road vehicular sources, as expeditiously as possible, to meet state ambient air quality standards (HSC §§ 43013 and 43018).

The federal Clean Air Act (CAA) section 209(e)(2) permits California to adopt emission standards for off-road[2] engines that are not otherwise expressly preempted under section 209(e)(1). Section 209(e)(1) provides that no state, including California, or any political subdivision thereof may adopt or enforce emission standards or other requirements relating to the control of emissions for new nonroad engines under 175 horsepower that are used in farm or construction equipment or used in locomotives or locomotive engines. California may, however, may adopt emission standards and requirements related to emission control for new and in-use nonroad engines that are not specifically preempted, so long as it obtains authorization from the Administrator of the U.S. EPA prior to the regulation becoming effective. As part of the authorization process, ARB must establish that the adopted regulations "will be, in the aggregate, at least as protective of public health and welfare as the applicable Federal standards.[3]

The in-use off-road diesel vehicles subject to this regulation are vehicular sources. As such, the proposed regulation would be adopted under the authority provided in HSC section 39667. The ARB is responsible for implementation and enforcement of the

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[1] California's Air Toxics Program, established under California law by AB 1807 (Stats. 1983, Ch. 1047) and set forth in HSC sections 39650 through 39675, mandates that ARB identify and control air toxics emissions in California. The identification phase of the Air Toxics Program requires the ARB, with participation of other state agencies, such as the Office of Environmental Health Hazard Assessment to evaluate the health impacts of, and exposure to, substances and to identify those substances that pose the greatest health threat as TACs. ARB's evaluation is then made available to the public and is formally reviewed by the Scientific Review Panel (SRP) established under HSC section 39670. Following the ARB's evaluation and the SRP's review, the Board may formally identify a TAC at a public hearing. The ARB identified particulate emissions from diesel-fueled engines (diesel PM) as a TAC in August 1998. Following the identification of a substance as a TAC, HSC §§ 39658, 39665, 39666, and 39667 require ARB, with the participation of the air pollution control and air quality management districts (districts), and in consultation with affected sources and interested parties, to prepare a report on the need and appropriate degree of regulation for that substance. The Board approved the *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* in September 2000 (ARB, 2000).

[2] The CAA refers to "nonroad engines" and California has historically referred to these same engines as "off-road engines." For purposes of this regulation the two terms are interchangeable.

[3] U.S. EPA is authorized by CAA section 213 to adopt emission standards and other regulations for only new non-road engines. In *Engine Manufacturers Association v. U.S. EPA* (D.C. Cir.1996) 88 F.3d 1075, the Court concluded that California is the only government body with authority to adopt emission standards and other regulations for in-use engines. (*Id.*, at 1089-1091.)

proposed regulation. Districts are not authorized to adopt requirements for vehicles subject to the proposed regulation.

A. References

ARB, 2000. California Air Resources Board. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles*. October 2000, p. 15 http://www.arb.ca.gov/diesel/documents/rrpapp.htm

III. PUBLIC OUTREACH AND ENVIRONMENTAL JUSTICE

ARB is committed to ensuring that all California communities have clean, healthful air by addressing not only the air quality issues confronting our cities but also the localized air quality impacts that are generated within our communities. The ARB works to ensure that all individuals in California, especially the children and elderly, can live, work and play in a healthful environment that is free from harmful exposure to air pollution. The proposed regulation's relationship to environmental justice is described in Section A below.

Staff conducted various outreach efforts to notify affected stakeholders of the proposed regulation and to give them opportunities to participate in the regulatory development process. These efforts are described further below in Section B.

A. Environmental Justice

As a matter of policy, ARB is committed to integrating environmental justice in all of its activities. On December 13, 2001, the Board approved Environmental Justice Policies and Actions, which formally established a framework for incorporating environmental justice into the ARB's programs, consistent with the directives of State law. Environmental justice is defined as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies (ARB, 2001). These policies apply to all communities in California, but recognize that environmental justice issues have been raised more in the context of low-income and minority communities.

As the proposed regulation would require cleaner fleets of in-use off-road diesel vehicles to be used throughout the state, it would reduce emissions in all communities in California, including those with environmental justice concerns. Staff are currently working to inform those in environmental justice communities of the proposed regulation and how the final implementation would reduce exposure to diesel PM and protect public health in their communities.

B. Outreach Efforts

As part of the public process, staff conducted various outreach efforts to notify affected stakeholders of the proposed regulation and to give them opportunities to participate in the regulatory development process. Staff held numerous public workshops and workgroup meetings throughout the state. Staff have also met with individual stakeholders and contacted various industries, associations, individual businesses, and other organizations to inform them of the proposed regulation. Staff also did two major mailings to licensed contractors in the State to inform them of the proposed regulation, a survey, and upcoming public meetings.

1. *Public Workshops*

Staff held 13 public workshops over the last two and a half years (since November 2004) to discuss development of the proposed regulation. The workshops were held in various locations throughout the State to allow stakeholders to participate in person or by webcast. Table III-1 shows the dates and locations of the workshops.

Table III-1 - Public Workshop Dates, Locations and Times

Date	Location
November 16, 2004	Sacramento
November 17, 2004	El Monte
July 13, 2005	El Monte
July 19, 2005	Sacramento
January 24, 2006	Sacramento
January 31, 2006	El Monte
December 18, 2006	Sacramento
December 20, 2006	Los Angeles
December 21, 2006	Fresno
February 20, 2007	San Diego
February 23, 2007	Fresno
February 26, 2007	Sacramento
March 1, 2007	Riverside

As the regulatory development process progressed, the workshops became better attended such that over 1,000 people cumulatively attended the last series of four workshops.

2. *Public Workgroup Meetings*

Staff also conducted six informal public workgroup meetings throughout the regulatory development process. These meetings were teleconferenced between El Monte and Sacramento, and stakeholders were also able to call in and participate by phone. Table III-2 lists the dates and location of these meetings.

Table III-2 - Public Workgroup Meetings

Date	Location
December 13, 2004	Sacramento and El Monte
February 16, 2005	Sacramento and El Monte
June 9, 2005	Sacramento and El Monte
August 30, 2005	Sacramento and El Monte
March 15, 2006	Sacramento and El Monte
July 21, 2006	Sacramento and El Monte

3. Other Outreach Efforts

Due to the variety of industries that utilize off-road vehicles, staff reached out to many different industries and associations. Table III-3 lists companies, associations and organizations that were contacted by staff to notify them of the proposed regulation. In addition, staff also sent mailings to over 4,000 landfills, recycling facilities, and mining facilities and over 500 small airports in the state (See Appendix B). Staff also sent letters to over 2,700 owners of portable equipment because many of them may also own mobile off-road vehicles (See Appendix B). Staff also contacted rental companies, public utilities, individual construction companies, and all of the major airports in California (Sacramento, San Francisco, Oakland, San Jose, Burbank, Ontario, Los Angeles, John Wayne, Long Beach, and San Diego) to notify them about the development of the proposed regulation and to encourage their participation.

Table III-3 - Companies, Associations, and other Organizations Contacted

AgCo	State License Board
Air Transport Association	Ditch Witch
Allmand Bros.	Engine Manufacturers Association
Army Corps of Engineers	Engineering Contractors Association
American Rental Association	Engineering and Utility Contractors Association
Asphalt Pavement Association	Genie
Associated California Loggers	Golf Course Superintendents Association
Associated General Contractors of California	Grove
Associated General Contractors of California, San Diego Chapter	Hyster
Association of Compost Producers	Hyundai
Association of Equipment Manufacturers	Industrial Workers of the World
Association of Energy Services Companies	International Association of Amusement Parks and Attractions
Automotive Trade Organizations of California	International Association of Drilling Contractors
ASV	International Trade and Transportation Center
BNSF	JCB
Bobcat	JLG/Grandall
Builder's Exchange	John Deere
California Building Industry Association	Johnson Matthey
California Cable	Kawaski
California Chamber of Commerce	Komatsu
California Department of Forestry	Kubota
California Department of General Services	League of California Cities
California Department of Transportation	Liebherr
California Enhanced Manufacturing Supply Chain	Link-Belt
California Forestry Association	Manitou
California Independent Oil Marketers	Manufacturers of Emission Controls Association

Association	Mason Contractors Association
California Local Air Pollution Control Districts	Mecom Equipment LLC
California Manufacturers and Technology Association	Motion Picture Association of America
California Mining Association	Mustang
California Rental Association	New Holland
California Retailers Association	Nissan
California Ski Industry Association	Northern CA Engineering Contractors Association
Case	Outdoor Amusement Business Association
Caterpillar	Regional Council of Rural Counties
Cemetery & Mortuary Association of California	Rick Albert Machinery
Construction Employers' Association	Silicon Valley Manufacturing Group
Construction Industry Air Quality Coalition	Southern California Contractors Association
Construction Materials Association of America	Terramite
Construction Materials Association of California	TLR Equipment Co., Inc.
Contractors	Toyota
California State Short Line Railroad Association	United Rental, Inc.
California State Association of Counties	Union Pacific
California Warehouse Association	Vermeer
	Volvo
	Western Fairs Association
	Western States Petroleum Association

Staff also conducted two major mailings to licensed contractors in California. The first mailing was done in July 2005, with letters sent to over 79,000 licensed contractors throughout the state from a mailing list provided by the Contractors State License Board (CSLB). Staff sent this mailing to licensed contractors with active or inactive licenses and had license classifications listed in Table III-4 and that would most likely own heavy-duty diesel off-road vehicles. The letter that was sent is in Appendix B. The letter informed the contractor of the development of the regulation and asked if they would like to receive further information either by email or regular mail and if they would like to participate in the ARB survey for in-use off-road vehicles.

Table III-4 - Licensed Contractor Classifications Contacted in July 2005

General Engineering
Concrete
Earthwork and Paving
Building Moving/Demolition
Landscaping
Masonry
Parking and Highway Improvement
Pipeline
Plumbing

Roofing Sanitation System General Manufactured Housing Swimming Pool Well Drilling Concrete – Related Services Drilling, Blasting and Oil Field Works Machinery and Pumps Pile Driving/Pressure Foundation Jacking Pole Installation and Maintenance Sand and Water Blasting Service Station Equipment and Maintenance Trenching Hydroseed Spraying Construction Cleanup

In February 2007, ARB sent a postcard (Appendix B) to over 290,000 licensed contractors using an expanded list from the CSLB that covered all licensed contractors in the state regardless of the license classification. The list included contractors with active or inactive licenses and those in arbitration. The postcard informed them of the proposed regulation and invited them to participate in upcoming public workshops.

During the first quarter of 2007, staff also contacted dozens of equipment dealers, those responsible for the majority of equipment sold in California, and asked them to send to their customers a flyer regarding the proposed rule. The names of the dealers ARB contacted are also listed in Table III-3. Staff also contacted the California Independent Oil Marketers Association and asked them to provide the flyer regarding the rule to buyers of diesel fuel. The flyer is included in Appendix B.

Over the last two and a half years, staff also met with individual companies and organizations to discuss the proposed regulation. Staff also made presentations to various companies and organizations. Table III-5 lists the dates and names of companies or organizations staff met with or made presentations to about the in-use off-road diesel vehicle proposed regulation.

Table III-5 - Meetings/Presentations by ARB Staff

Date	Company/Organization
12/16/04	Rural Counties Joint Power Authority
12/21/04	Teichert (Site visit)
6/27/05	American Rental Association
7/13/05	John Deere
8/9/05	Granite Construction
8/23/05	Construction Industry Air Quality Coalition
8/31/05	Union of Concerned Scientists
9/12/05	United Airlines

Date	Company/Organization
9/20/05	United Airlines (Site visit)
10/27/05	Granite Construction
11/9/05	Union of Concerned Scientists, American Lung Association, etc.
3/1/06	Construction Material Association of California
3/13/06	American Lung Association
3/16/06	Air Transport Association
3/30/06	Teichert (Site visit)
4/18/06	Granite Construction
4/27/06	Construction Industry Air Quality Coalition
5/25/06	Air Transport Association
6/20/06	Caterpillar
8/1/06	Union of Concerned Scientists
8/9/06	Siskiyou and Glenn Counties
8/14/06	Holt of California
8/15/06	CC Meyers
8/16/06	American Rental Association
8/18/06	Construction Industry Air Quality Coalition
8/21/06	Nabors Drilling
8/30/06	CC Meyers
8/30/06	MCM Construction
9/13/06	United Rentals
9/26/06	Air Transport Association
11/7/06	Regional Council of Rural Counties
11/9/06	Engineering Contractors Association (Santa Rosa)
11/20/06	Union of Concerned Scientists
11/27/06	Delta Construction
12/1/06	California Department of Transportation
12/6/06	Construction Industry Air Quality Coalition
1/4/07	Regional Council of Rural Counties (site visit to Lake and Calaveras Counties)
1/9/07	Construction Industry Air Quality Coalition
1/10/07	Holt of California
1/16/07	Sukut Contruction
1/23/07	Compaction Rentals/Hobday Equipment
1/24/07	North Coast Builders Exchange
1/25/07	Construction Industry Air Quality Coalition
2/6/07	Sierra County Board of Supervisors
2/7/07	Bobcat
2/7/07	Robison Industries
2/8/07	Sierra Cascade Logging Conference
2/9/07	Construction Industry Air Quality Coalition
2/22/07	Delta Construction
2/28/07	Blue Mountain Mining

Date	Company/Organization
3/6/2007	Contractors Association of Truckee Tahoe
3/13/2007	Association of Energy Services Companies
3/22/2007	Construction Industry Air Quality Coalition
3/22/2007	Holt of California, Pleasant Grove
3/23/2007	Holt of California, Stockton
3/27/2007	Construction Industry Air Quality Coalition

C. Future Efforts

If the proposed regulation is adopted, staff will continue its outreach efforts to associations and other affected stakeholders to assist with implementation. Staff has also established a toll free phone number, 866-6DIESEL, to assist affected stakeholders in obtaining information on how to comply with the regulation if adopted.

During implementation of the regulation, staff will work with affected stakeholders to educate them on meeting the requirements. This would include holding public workshops, seminars, and individual meetings throughout the State on how to meet the requirements of the regulation, and to strengthen enforcement and compliance. Staff plan to create a reporting system and tools to assist fleets in determining what compliance options are available and in developing their own compliance plans. Staff also plan to continue to work with industry representatives and associations on additional ways to educate different stakeholders.

D. References

ARB, 2001. California Air Resources Board, *Policies and Actions for Environmental Justice Staff Report*. December 13, 2001.

IV. NEED FOR EMISSION REDUCTIONS

Many areas in the State still exceed state and federal ambient air quality standards (that is, are non-attainment areas). More than any other air pollution control effort, California's mobile source emissions control programs have helped to move the state's nonattainment areas closer to meeting federal and state ambient air quality standards (AAQS). These programs have provided major statewide reductions in emissions of carbon monoxide (CO), particulate matter (PM), sulfur oxides (SOx), and ozone precursors – nitrogen oxides (NOx) and volatile organic compounds (VOCs, also called reactive organic gases or ROG). However, even with the success of existing programs, over 90 percent of Californians still experience unhealthy levels of air pollution. Substantial new reductions in mobile source emissions are essential if the state is to attain and maintain the state and national AAQS. In addition, reducing diesel particulate matter emissions from mobile sources is critical to reducing overall public exposure to ambient air toxic contaminants.

A. Ozone and its Precursors

Ground level ozone is the primary constituent of smog. Ozone precursors include nitric oxide and nitrogen dioxide, collectively referred to as NOx, and VOCs. Ozone is formed in the atmosphere by the reaction of VOCs and NOx in the atmosphere in the presence of heat and sunlight. The highest levels of ozone are produced when both VOC and NOx emissions are present in significant quantities on clear summer days. Measures that reduce the emissions of ozone precursors will also reduce the ambient concentration of ozone.

1. Ambient Air Quality Standards for Ozone

State and federal AAQS have been established for ozone, as shown in Table IV-1. Currently, there are two State standards for ozone: a 1-hour standard which has been in effect since 1987, and a new 8-hour standard that became effective May 17, 2006. This new 8-hour standard was based on the results of an evaluation of the adequacy of the 1987 standard, as required by the Children's Environmental Health Protection Act (Senate Bill 25, Escutia, 1999). Senate Bill 25 (SB25) directed the ARB, in consultation with the Office of Environmental Health Hazard Assessment (OEHHA), to "review all existing health-based ambient air quality standards to determine whether these standards protect public health, including infants and children, with an adequate margin of safety. In July 1997, the U.S. EPA promulgated a new national 8-hour ozone standard (replacing the previous federal 1-hour standard) effective September 1997, and in 2004 issued new area designation maps for the new standard. The national 1-hour ozone standard was revoked effective June 15, 2005, for all areas except the 8-hour ozone non-attainment Early Action Compact areas that have deferred effective dates for their designations under the 8-hour ozone standard.

Table IV-1 - State and National Ozone Ambient Air Quality Standards[4]

Averaging Time	California Standard	National Standard
1-hour	0.09 ppm (180 µg/m^3)	--[5]
8-Hour	0.070 ppm (137 µg/m^3)	0.08 ppm (157 µg/m^3)

Because the new 8-hour State standard is more health protective than the 1-hour standard, it tends to determine the ozone area designations. As a result, a large number of areas that were formerly designated as attainment, unclassified, or transitional-attainment for ozone based on the 1-hour standard will now be classified as nonattainment based on the 8-hour standard (ARB, 2006a).

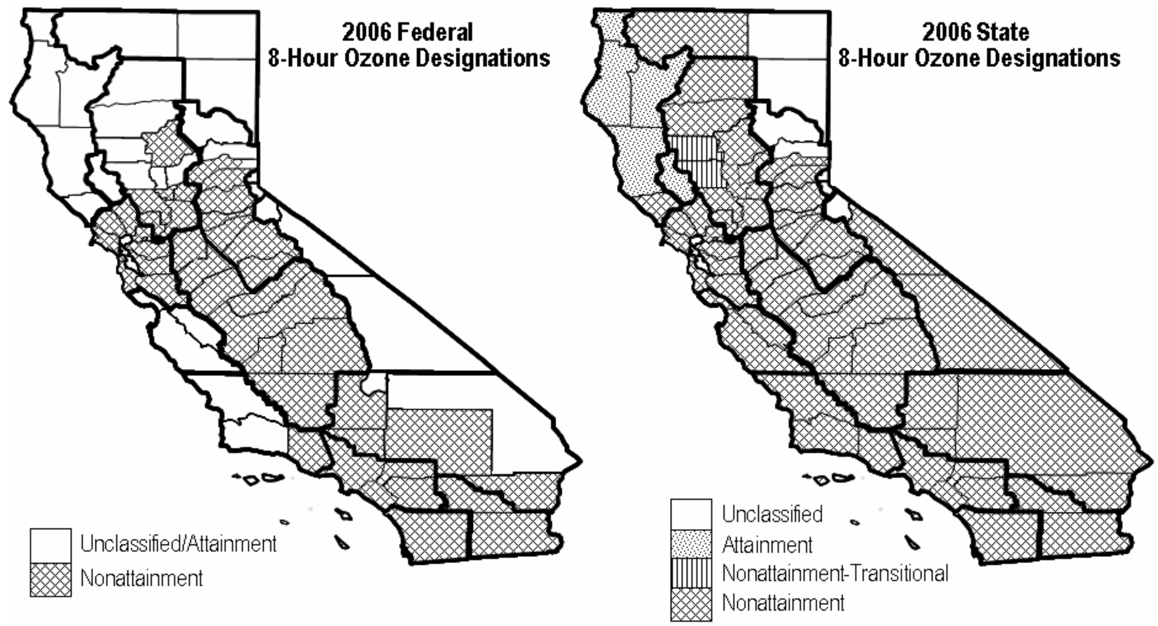
In November 2006, the Board approved proposed changes to the State area designations based on the new 8-hour ozone standard. As shown in Figure IV-1, most of California does not meet the State's AAQS for ozone. The Lake County Air Basin continues to be in attainment, and in the North Coast Air Basin, Del Norte, Humboldt, Trinity, and Mendocino counties continue to be in attainment, but Sonoma County has been changed from attainment to nonattainment.

Figure IV-1 also shows that many areas in the state violate the federal 8-hour ozone standard. The U.S. EPA has designated 15 areas in California as nonattainment for the federal 8-hour ozone standard. These areas include the San Joaquin Valley, the South Coast Air Basin, Sacramento region, San Diego, Ventura, the San Francisco Bay Area, and a number of air districts downwind of urban areas.

[4] ppm= parts per million, µg/m^3=micrograms per cubic meter

[5] The U.S. EPA revoked the national 1-hour ozone standard effective June 15, 2005.

Figure IV-1 - Federal and State Area Designations for Ozone



Substantial new ozone precursor emission reductions are needed not only to achieve attainment for the 8-hour state and federal ozone standards, but also to meet progress requirements for the ozone standard required under California law. The greatest emissions reductions are needed in the South Coast and San Joaquin Valley Air Basins. Given the severity of their ozone problems, both of these regions will likely be classified as "extreme" for ozone with 2024 deadlines.

2. Ambient Air Quality Standards for Nitrogen Dioxide (NO_2)

The primary sources of nitrogen dioxide (NO_2) are internal combustion engines, both gasoline and diesel powered, and point sources such as power plants. NO_2 is also formed indirectly from emissions of nitric oxide (NO) that are converted photochemically to NO_2. Both NO and NO_2 are involved in a series of chemical reactions in the ambient air to produce additional pollutants such as ozone, nitric acid, nitrate aerosols, and other nitrogen-containing compounds that are toxic. Of the nitrogen oxide compounds (NOx) in the atmosphere, NO_2 represents the greatest risk to human health (Frampton, 2000).

The U.S. EPA has established a national AAQS for NO_2 of 0.053 parts per million (ppm) averaged over one year. The ARB established a short-term (1-hour) standard for NO_2 of 0.25 ppm, averaged over one hour. As required by SB25, staff of ARB and OEHHA reviewed the scientific basis for California's ambient standard for NO_2 to determine its adequacy to protect public health, including the health of infants and children. Staff found that health effects may occur at levels near the existing standard of 0.25 ppm, and recommended that the level of the California ambient air quality standard for NO_2 be lowered to 0.18 ppm, averaged over one hour. OEHHA staff also recommended the addition of an annual average standard of 0.03 ppm (ARB, OEHHA, 2007)

Though the state and federal NO_2 standards are not exceeded, NO_2 is still a concern because it is a precursor to both ozone and particulate matter. Secondary ammonium nitrate is formed from the oxidation NOx to nitric acid followed by the reaction of nitric acid with gaseous ammonia. The oxidation of NOx to nitric acid can occur during the daytime through reactions involving the hydroxyl radical and during the nighttime through reactions with ozone and water. Secondary ammonium nitrate is a significant component of particulate emissions in the South Coast. Therefore, reducing ammonium nitrate through controls on NOx sources is a critical part of the State's PM strategy.

3. Health Effects of Ozone

Ozone is a powerful oxidant that can have substantial health impacts even at very low levels. Scientific studies show that exposure to ozone can result in reduced lung function, increased respiratory symptoms, increased airway hyperreactivity, and increased airway inflammation. Exposure to ozone is also associated with premature death, hospitalization for cardiopulmonary causes, emergency room visits for asthma, and restrictions in activity (ARB, 2005a)

Short-term exposure to high ambient ozone concentrations have been linked to increased hospital admissions and emergency visits for respiratory problems (U.S. EPA, 2000). Repeated exposure to ozone can make people more susceptible to respiratory infection and lung inflammation and can aggravate pre-existing respiratory diseases, such as asthma. Prolonged (6 to 8 hours), repeated exposure to ozone can cause inflammation of the lung, impairment of lung defense mechanisms, and possibly irreversible changes in lung structure, which over time could lead to premature aging of the lungs and/or chronic respiratory illnesses such as emphysema and chronic bronchitis.

Those most susceptible to ozone health effects include individuals exercising outdoors, children and people with pre-existing lung disease such as asthma, and chronic pulmonary lung disease. Children are more at risk from ozone exposure because they typically are active outside during the summer when ozone levels are highest. Also, children are more at risk than adults because their respiratory systems are still developing. Adults who are outdoors and moderately active during the summer months, such as construction workers and other outdoor workers, also are among those most at risk. These individuals, as well as people with respiratory illnesses such as asthma, especially asthmatic children, can experience reduced lung function and increased respiratory symptoms, such as chest pain and cough, when exposed to relatively low ozone levels during prolonged periods of moderate exertion.

Reducing emissions of ozone precursors would reduce the prevalence of the types of respiratory problems associated with ozone exposure and would reduce hospital admissions and emergency visits for respiratory problems.

B. Particulate Matter

Ambient particulate matter (PM) is a complex mixture of very small particles and liquid droplets in the air. Ambient PM is comprised of directly emitted PM such as dust and soot, known as primary PM, as well as secondary PM formed in the atmosphere from the reactions of precursor gases, such as NOx, SOx, VOCs and ammonia (ARB, 2005b). Nitrogen oxides, SOx, and ammonia combine to form secondary ammonium nitrate and sulfate. Volatile organic compounds can form secondary organic aerosols as well as participate in the production of secondary ammonium nitrate. Particles with diameter less than or equal to 10 microns are referred to as PM10 and particles up to 2.5 microns in diameter are referred to as PM2.5. Those particles with diameter between 2.5 and 10 microns are referred to as coarse particles while PM2.5 are described as fine particles. PM2.5 is therefore a subset of PM10. In general, combustion processes form fine particles, while emissions from dust sources tend to be predominantly coarse particles.

The health and environmental effects of PM are related to the size of the particles. Fine particles can remain in the atmosphere for days to weeks and travel through the atmosphere for hundreds to thousands of kilometers, while coarse particles deposit to the earth within minutes to hours and within tens of kilometers from the emission source. Particles in the PM2.5 size range can penetrate into the deepest regions of the lungs.

1. Ambient Air Quality Standards for PM

The ARB and the U.S. EPA have adopted health-based ambient air quality standards for PM10 and PM2.5. In September 2006, the U.S. EPA lowered the short-term ambient air quality standard for PM2.5 from 65 micrograms per cubic meter ($\mu g/m^3$) to 35 $\mu g/m^3$ and revoked the annual standard for PM10. Table IV-2 shows the current federal and state standards. California's ambient air quality standards for PM are more stringent than the national standards and, like the ozone standards, are intended to provide protection for the most sensitive groups of citizens, including infants and children, the elderly, and persons with heart or lung disease.

Table IV-2 - State and National PM Ambient Air Quality Standards ($\mu g/m^3$)

Standard		California	National
PM10	Annual Arithmetic Mean	20	--[6]
	24-Hour Average	50	150
PM2.5	Annual Arithmetic Mean	12	15
	24-Hour Average	--[7]	35

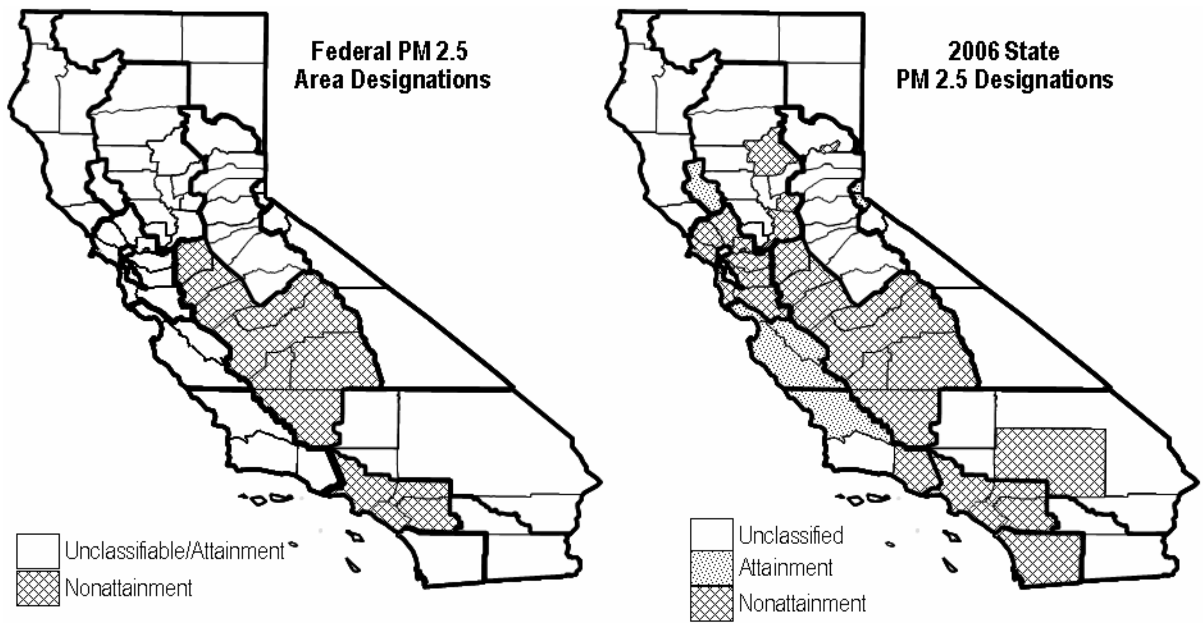
Most of California is designated as non-attainment for the State PM10 standard. Currently, the only areas that attain the State PM10 standard are the Lake County Air

[6] The U.S. EPA recently rescinded the annual PM10 standard of 50 $\mu g/m^3$.

[7] No separate State standard.

Basin and Siskiyou County in the Northeast Plateau Air Basin. The portion of Sonoma County in the North Coast Air Basin has been recommended for redesignation as attainment for PM10 (ARB, 2006). With respect to the national 24-hour PM10 standard, the San Joaquin Valley, the South Coast and several desert areas are in non-attainment. As shown in Figure IV-2, most urban areas and several isolated sub-areas are in nonattainment for the State PM2.5 standard. However, the only Federal nonattainment areas for the national annual average PM2.5 standard are the San Joaquin Valley and the South Coast.

Figure IV-2 - Federal and State Area Designations for PM2.5



Because of the State's nonattainment status, PM emissions reduction remains one of California's highest public health priorities. The nonattainment areas with serious problems will require substantial reductions of directly emitted PM2.5 pollutants and PM2.5 precursors. Based on atmospheric modeling performed by ARB staff, control of the emissions of ozone precursors (and in particular NOx) may provide significant benefit due to the reduction in ambient concentrations of nitrate which is an important component of ambient PM2.5.

2. Health Effects of Particulate Matter

There are strong and consistent associations between daily exposure to PM (measured as PM10, PM10-PM2.5, or PM2.5) and a range of adverse health outcomes. These include premature mortality, aggravation of respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits, school absences, work loss days, and restricted activity days), asthma exacerbation, chronic and acute bronchitis, and reductions in lung function. The more severe outcomes are experienced primarily by the elderly and people with pre-existing chronic heart and lung disease. Children under age five may also experience serious adverse outcomes from exposure to PM10, including premature mortality and hospitalization for respiratory conditions (ARB, OEHHA 2002).

The annual average state standard for PM10 was lowered in 2002 from 30 ug/m^3 to the current standard of 20 ug/m^3 after an evaluation by ARB and OEHHA staff of the literature on health effects associated with PM at or below 30 ug/m^3. Attainment of California's standards would result in the yearly prevention of an estimated 6,500 premature deaths, approximately 400,000 incidences of lower respiratory symptoms among children ages seven to fourteen, and over two million lost workdays (ARB, 2005b).

Almost all of diesel PM is in the fine particle fraction (PM2.5). Because of its significance also as a toxic air contaminant, diesel PM is discussed separately later in this chapter.

C. Toxic Air Contaminants

1. Components of Diesel Exhaust

Diesel engines emit a complex mixture of inorganic and organic compounds that exist in gaseous, liquid, and solid phases. The composition of this mixture will vary depending on engine type, engine age and horsepower, operating conditions, fuel, lubricating oil, and whether or not an emission control system is present. The primary gas or vapor phase components of diesel exhaust include typical combustion gases and vapors such as CO, carbon dioxide, sulfur dioxide, NOx, ROG, water, and excess air (nitrogen and oxygen).

Diesel exhaust contains over 40 substances listed in Table IV-3 that have been listed as toxic air contaminants (TACs) by the state of California and as hazardous air pollutants by the U.S. EPA. Fifteen of these substances are listed by the International Agency for Research on Cancer (IARC) as carcinogenic to humans, or as a probable or possible human carcinogen (ARB, 1998). The U.S. EPA also classified diesel exhaust as likely to be carcinogenic to humans by inhalation at environmental exposures (U.S. EPA, 2002).

Table IV-3 - Substances in Diesel Exhaust Listed by California as Toxic Air Contaminants

Acetaldehyde	Formaldehyde
Acrolein	Inorganic lead
Aniline	Manganese compounds
Antimony compounds	Mercury compounds
Arsenic	Methanol
Benzene	Methyl Ethyl Ketone
Beryllium compounds	Naphthalene
Biphenyl	Nickel
Bis[2-ethylhexyl]phthalate	4-Nitrobiphenyl
1,3-Butadiene	Phenol
Cadmium	Phosphorus
Chlorine	Polycyclic organic matter, including polycyclic aromatic hydrocarbons (PAHs) and their derivatives
Chlorobenzene	Propionaldehyde
Chromium compounds	Selenium compounds
Cobalt compounds	Styrene
Creosol isomers	Toluene
Cyanide compounds	Xylene isomers and mixtures
Dibutylphthalate	o-Xylenes
Dioxins and dibenzofurans	m-Xylenes
Ethyl benzene	p-Xylenes

2. Diesel Particulate Matter

Diesel particulate matter is either directly emitted from diesel-powered engines (primary particulate matter) or is formed from the gaseous compounds emitted by a diesel engine (secondary particulate matter). Diesel PM consists of both solid and liquid material and can be divided into three primary constituents: the elemental carbon fraction (ECF); the soluble organic fraction (SOF), and the sulfate fraction.

Many of the diesel particles exist in the atmosphere as a carbon core with a coating of organic carbon compounds, or as sulfuric acid and ash, sulfuric acid aerosols, or sulfate particles associated with organic carbon (Kittelson et al., 1999). Diesel PM can be distinguished from noncombustion sources of PM2.5 by the high content of elemental carbon and the high number of ultrafine particles (organic carbon and sulfate).

The soluble organic fraction (SOF) consists of unburned organic compounds which condense into liquid droplets or are adsorbed onto the surfaces of the elemental carbon particles. Several components of the SOF have been identified as individual toxic air contaminants. The organic fraction of the diesel particle contains compounds such as aldehydes, alkanes and alkenes, and high-molecular weight polycyclic aromatic hydrocarbons (PAH) and PAH-derivatives. Many of these PAHs and PAH-derivatives, especially nitro-PAHs, have been found to be potent mutagens and carcinogens.

Nitro-PAH compounds can also be formed during transport through the atmosphere by reactions of adsorbed PAH with nitric acid and by gas-phase radical-initiated reactions in the presence of NOx. Atmospheric reactions of these gas phase PAH and nitro-PAH derivatives may lead to the formation of several mutagenic nitro-PAH, and nitro-PAH compounds, including nitrodibenzopyranones, 2-nitroflouranthene and 2-nitropyrene (Arey et al., 1988).

Almost all of the diesel particle mass is in the PM10 fraction, and approximately 94 percent of the mass of these particles is less than 2.5 microns in diameter (PM2.5). The particles have a very large surface area per unit mass which makes them excellent carriers for many of the organic compounds and metals found in diesel exhaust. Because of their small size, the particles are readily respirable and can effectively reach the lowest airways of the lung along with the adsorbed compounds, many of which are known or suspected mutagens and carcinogens (ARB, 1998).

Diesel PM was identified by the Board as a TAC in 1998 after an extensive review and evaluation of the scientific literature by OEHHA and subsequent review by the Scientific Research Panel (SRP). In 2001, the U.S. EPA identified diesel particulate matter and diesel exhaust organic gases as a Mobile Source Air Toxic (MSAT) (U.S. EPA,2001).

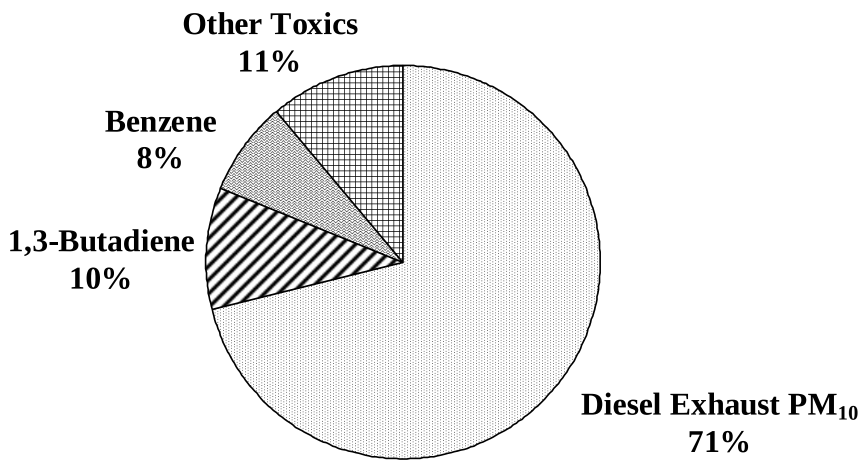
D. Health Impacts of Exposure to Diesel Exhaust and Diesel PM

Diesel PM, with the associated organic compounds, plays a key role in the carcinogenicity and chronic noncancer effects of exposure to diesel exhaust. The findings from more than 30 human epidemiological studies indicate that on average, long-term occupational exposures to diesel exhaust were associated with a 40 percent increase in the relative risk of lung cancer (OEHHA, 1998). However, there is limited specific information that addresses the variable susceptibilities to the carcinogenicity of diesel exhaust within the general human population and vulnerable subgroups, such as infants and children and people with pre-existing health conditions. The carcinogenic potential of diesel exhaust was also demonstrated in numerous genotoxic and mutagenic studies on some of the organic compounds typically detected in diesel exhaust (OEHHA, 1998).

Health impacts from exposure to the PM2.5 component of diesel exhaust have been calculated for California, using concentration-response equations from several epidemiologic studies. Both mortality and morbidity effects could be associated with exposure to either direct diesel PM2.5 or indirect diesel PM2.5, the latter of which arises from the conversion of diesel NOx emissions to PM2.5 nitrates. It was estimated that 2000 and 900 premature deaths resulted from long-term exposure to either 1.8 $\mu g/m^3$ of direct PM2.5 or 0.81 $\mu g/m^3$ of indirect PM2.5, respectively, for the year 2000 (Lloyd and Cackette, 2001). The mortality estimates are likely to exclude cancer cases, but may include some premature deaths due to cancer, because the epidemiologic studies did not identify the cause of death. Exposure to fine particulate matter, including diesel PM2.5, can also be linked to a number of heart and lung diseases. Another highly significant health effect of diesel exhaust exposure is its apparent ability to act as an adjuvant in allergic responses and possibly asthma (Diaz-Sanchez et al., 1996, 1999, Takano et al., 1998). However, additional research is needed at diesel exhaust concentrations that more closely approximate current ambient levels before the role of diesel exhaust exposure in the increasing allergy and asthma rates is established.

Diesel PM is a major contributor to potential ambient risk levels. Using the cancer unit risk factor developed by OEHHA for the TAC program, it was estimated that for the year 2000, exposure to ambient concentrations of diesel (1.8 $\mu g/m^3$) could be associated with a health risk of 540 potential cancer cases per million people exposed over a 70-year lifetime. This diesel PM cancer risk accounted for approximately 70 percent of the total risk associated with all known ambient air toxics as shown in Figure IV-3.

Figure IV-3 - State Average Potential Cancer Risk from Outdoor Ambient Levels of Toxic Pollutants for the Year 2000[8,9,10]



The South Coast Air Quality Management District Multiple Air Toxics Exposure Study II (MATES II) estimated that the average potential cancer risk in the South Coast Air Basin from diesel PM was about 1000 excess cancers per million people, or 71 percent of the average cancer risk from all air toxics in the South Coast Air Basin. For localized or near-source exposures to diesel exhaust, such as might occur near busy roads and intersections, the potential risks will be much higher.

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[8] ARB 2000

[9] Diesel exhaust PM_{10} potential cancer risk based on 2000 emission inventory estimates. All other potential cancer risks based on air toxics network data. Used 1997 data for para-dichlorobenzene. Used 1998 monitoring data for all others. Assumes measured concentrations are equivalent to annual average concentrations and duration of exposure is 70 years, inhalation pathway only.

[10] Includes carbon tetrachloride (4percent), formaldehyde (2.5percent), hexavalent chromium (2.2 percent), para-dichlorobenzene (1.2 percent), acetaldehyde (0.7 percent), perchloroethylene (0.7 percent), and methylene chloride (0.3 percent).

1. Health Impacts of Exposure to Diesel PM from Off-Road Diesel Vehicles

A substantial number of epidemiologic studies have found a strong association between exposure to ambient particulate matter (PM) and adverse health effects (ARB, OEHHA, 2002). Staff quantified the statewide impact of several non-cancer health impacts associated with diesel PM emissions from off-road diesel engines in California in 2005. The non-cancer health effects include premature death, asthma attacks, acute bronchitis, hospital admissions, work loss days, and minor restricted activity days.

The health outcomes take into account a number of factors including the relationship between air pollutant concentrations and the effect found in health studies, the relative contribution of emission sources to the pollutant in a region, and the population in a region. The regional impacts, by air basin, were added together to provide a statewide total. A description of the Appendix C provides a description of the methodology used to quantify the health impacts reported in this section.

Staff estimates that in the year 2005, approximately 1,100 premature deaths were associated with the baseline uncontrolled emissions from in-use off-road diesel vehicles subject to the proposed regulation. Table IV-4 shows the range and the average number of cases statewide in 2005 for each health impact evaluated by staff. The analysis included health impacts of direct diesel PM and indirect diesel PM – nitrates formed from precursor NOx emitted by off-road diesel engines. The impacts of direct and indirect sources of PM are listed separately in Table IV-4. The health impacts of NOx as a precursor to ozone are not included in the estimates. Appendix C provides a description of the methodology used to generate these estimates. Because only a subset of health outcomes was considered, the estimates in Table IV-4 should be considered an underestimate of the total public health impact of diesel PM exposure.

Table IV-4 - Health Impacts of Baseline 2005 Emissions from In Use Off-Road Diesel Vehicles Covered by the Regulation

Endpoint	Pollutant	Number of Cases (Mean)	Range (95% C.I.)
Premature Mortality	NOx	450	120 - 770
	PM	690	190 - 1,200
	Total	1,100	310 - 1,900
Hospital admissions (Respiratory)	NOx	100	60 - 130
	PM	150	90 - 200
	Total	240	150 - 330
Hospital admissions (Cardiovascular)	NOx	180	110 - 270
	PM	270	170 - 420
	Total	440	280 - 690
Asthma & Lower Respiratory Symptoms	NOx.	13,000	5,000 - 20,000
	PM	19,000	7,400 - 31,000
	Total	32,000	12,000 - 51,000
Acute Bronchitis	NOx	1,100	0 - 2,300
	PM	1,600	0 - 3,500
	Total	2,600	0 - 5,700
Work Loss Days	NOx	77,000	65,000 - 89,000
	PM	120,000	100,000 - 140,000
	Total	190,000	170,000 - 220,000
Minor Restricted Activity Days	NOx	440,000	360,000 - 520,000
	PM	680,000	550,000 - 800,000
	Total	1,100,000	920,000 - 1,300,000

The health impacts from in-use off-road diesel vehicles are significant. To put the magnitude of the impact in context, off-road diesel vehicles covered by the proposed regulation are equivalent to nearly one third of the number of deaths due to environmental tobacco smoke (secondhand smoke) and one fourth the number of deaths due to motor vehicle accidents. Secondhand smoke is estimated to cause to 4,021 premature deaths per year in California (ARB, 2006b), while motor vehicle accidents killed 4,329 people in California in 2005 (NCSA, 2005).

E. Potential Risk from Exposure to Diesel PM Emissions from Off-Road Vehicles

Staff estimated the potential cancer risk from exposure to diesel PM emissions from diesel-fueled construction equipment operations in an urban area. The estimated risks and the assumptions used to determine these risks are based on a generic rather than a specific construction site. This methodology is commonly used as a tool to estimate risk, from a generic perspective, from a particular activity. The results from this assessment can then be over-laid on an actual population (that is, those living near a potential construction site), to quantify risk from an actual project. Because staff's assessment was generic in nature, an actual number of affected individuals cannot be quantified, as any estimate would vary based on local population density (that is, the more people near the site, the greater number of affected individuals.).

The analysis provided a range of potential risk to nearby communities from a year long construction project at a site the size of a typical city block. Using activity data (including equipment type, hours of operation, horsepower, and load factor) for a typical construction project, the risk was determined for five phases of the project: demolition, dewatering, grading/construction, construction, and pavement.

Two emissions scenarios were used – one that reflects an actual vehicle fleet that might be used in the construction project and a worst case scenario that assumed that all vehicles were old and met the Tier 0 emission standard. Dispersion modeling was used to estimate the ambient concentration of diesel PM resulting from the construction project. For the air dispersion model, meteorological conditions were chosen to represent atmospheric conditions more favorable to dispersion and more unfavorable conditions that would result in less dispersion of pollutants and provide a more conservative estimate of potential risk to nearby communities. Also, different release heights for the plume were selected for the different scenarios. The residents' exposure duration was assumed to be 9 years, 50 weeks per year and the operation schedule was assumed to be 365 days a year 8 hours per day from 9 AM to 4 PM. The worst-case scenario combined unfavorable meteorological conditions, the dirtiest engines, and the lowest initial release height of the plume. Appendix D provides the details of the scenarios and the methodology used to determine the risk.

Risk levels vary due to site specific parameters, including: number of equipment, type of equipment, emission rates, operating schedules, site configuration, site meteorology, and distance to receptors. The analysis showed that cancer risks from such a project were not insignificant, but were much less than other large point sources that have been evaluated such as ports, rail yards, and distribution centers.

Even under the worst case scenario, the construction project would generate risks greater than 10 in a million for an area of only 26 acres surrounding the project. The actual numbers of affected individuals would depend on the population around a specific project. A cancer risk of 10 in a million is the most commonly used threshold above which facilities are required by the Air Toxics Hot Spots Information and Assessment Act to notify all exposed persons (ARB, 2005c). By comparison, the combined risk from the Ports of Long Beach and Los Angeles is estimated to subject an area of over 163,000 acres and over 2,000,000 people to a cancer risk of over 10 in a million, with 2,500 acres and 53,000 people subject to much higher risks of over 500 in a million (ARB, 2005d).

As the proposed regulation is implemented, the statewide construction fleet would become dramatically cleaner and staff's modeling indicates that the associated cancer risk from these types of construction projects would drop significantly.

F. Diesel PM Risk Reduction

In 1998, the Board identified diesel PM as a toxic air contaminant and a needs assessment for diesel PM was conducted between 1998 and 2000. In 2000, the ARB adopted the *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles (Diesel Risk Reduction Plan or Plan)*. The scope of the Diesel RRP was broad, addressing all categories of engines, both mobile and stationary, and included control measures for private and public fleets of off-road diesel vehicles, such as those covered by the proposed regulation. The plan identified a strategy to regulate different categories of diesel emissions sources to achieve 75 percent reduction of diesel PM emissions by 2010 and 85 percent reduction by 2020 from the 2000 baseline. Over the last several years the Board has adopted a series of regulations to address diesel particulate matter emissions from the following sources:

- Solid waste collection vehicles (ARB, 2003a);
- Transit buses (ARB, 2005e);
- Transit fleet vehicles (ARB, 2005f);
- On-road public fleets and utility fleets (ARB, 2005g);
- Cargo handling equipment at ports and intermodal railyards (ARB, 2005h);
- Stationary diesel engines (ARB, 2003b);
- Portable equipment (ARB, 2004);
- Ship auxiliary engines (ARB, 2005i);
- Transport refrigeration units (ARB, 2003c);
- School bus idling (ARB, 2002); and
- Commercial vehicle idling (ARB, 2005j).

Historically, diesel engines have had very long useful lives with the capability of being rebuilt numerous times. For older engines, retrofit programs and accelerated turnover to cleaner engines must play an important role in achieving the ARB's near-term air quality goals. This proposed regulation for in-use diesel off-road vehicles is the next in this series of regulations to be considered by the Board. The Board will also continue to consider additional source categories to address the emissions from the remaining diesel engines in California.

The regulations mentioned above have either been structured to require best available control technology (BACT) from each engine or to require that fleets meet fleet average emission rates. As discussed further in Chapter VII, the proposed rule incorporates elements of both approaches. The school bus idling and commercial vehicle idling regulations also limit idling of diesel engines.

G. State Implementation Plan Commitments

Fifteen areas throughout the State, including the South Coast Air Basin, the San Joaquin Valley, the Sacramento region, San Diego, Ventura, and a number of air districts downwind of urban areas, are currently in violation of the national ozone AAQS. In addition, there are two areas – the South Coast Air Basin and the San Joaquin Valley – that do not meet the national PM2.5 AAQS. Areas that exceed the federal air quality standards are required by federal clean air laws to develop State Implementation Plans (SIP) describing how they will attain national AAQS. California is currently in the process of planning how to achieve the emissions reductions necessary to meet new health-based federal air quality standards for ozone and PM2.5. The Ozone SIP must be submitted to the U.S. EPA by June 15, 2007 while the PM2.5 SIP submittal date is April 5, 2008.

Ozone attainment deadlines vary throughout the State (from 2009 to 2021). It is expected that all of the ozone nonattainment areas except the South Coast Air Basin and the San Joaquin Valley will be able to show attainment by 2021 or earlier with identified measures. The current ozone attainment deadlines for the south Coast and San Joaquin Valley are 2021 and 2013, respectively. However, modeling results indicate that more time and reductions will be needed in the South Coast and the San Joaquin Valley – both of which are expected by ARB staff to be reclassified as extreme with a 2024 deadline.

Under the federal CAA, both the South Coast and San Joaquin Valley are required to attain the PM2.5 standard by 2015. In addition to reductions in directly emitted diesel PM, these areas must achieve significant reductions of NOx (a precursor to PM in the atmosphere) from the off-road sector to achieve the PM2.5 AAQS by the federally-mandated deadlines. Although both regions are showing good progress, PM2.5 attainment is still a significant challenge as the South Coast PM2.5 levels are still about 50 percent above the standard, and the San Joaquin Valley levels are about 25 percent above the standard (ARB, 2007).

While all sources of NOx emissions are important, off-road diesel vehicles are one of four major categories that will determine whether California is able to meet the 2014 deadline for PM2.5 attainment in the South Coast Air Basin. As new diesel engines have become cleaner, the emissions contribution from older vehicles has grown to the extent that it will soon make up the majority of mobile source emissions (ARB, 2007). With normal turnover of older vehicles and equipment, the newer lower emitting engines are introduced into the fleet relatively slowly, and consequently, the emissions reductions from normal turnover are slow to materialize. As a result, it has become important to accelerate the introduction of cleaner engines into California fleets. Most of the proposed new measures in the State strategy are designed to clean up or replace older, dirtier vehicles and equipment for which implementation will extend past 2010 through 2014 (ARB, 2007).

The reductions provided by the proposed off-road regulation will be substantial but staff expects that despite a comprehensive effort to achieve reductions from all possible sources to meet the PM2.5 standard, California may still come up short of achieving the needed emission reductions by the 2015 attainment deadline. Because the standard is an annual average, the U.S. EPA requires that all necessary emission reductions be achieved one calendar year sooner, or by 2014.

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V. OFF-ROAD VEHICLE DESCRIPTIONS AND NEW ENGINE STANDARDS

This chapter describes the diverse array of vehicles that would be subject to the proposed regulation. It includes a description and photographs of some of the vehicle types affected, a list of which manufacturers make affected vehicles, and a description of the various industries that own affected fleets. Finally, the chapter includes a summary of the standards for new engines and the technologies being utilized to reduce emissions from the affected engines and vehicles.

A. Overview

The off-road diesel-powered mobile vehicles that would be subject to the requirements of this regulation are a diverse group. These off-road vehicles are used by industries such as construction, mining, landscaping, airlines, retail, wholesale, equipment rental, ski, oil and gas drilling, recycling, utilities, telephone and cable, and many others. Government agencies engaged in road maintenance and other activities also utilize affected vehicles.

The regulation applies only to self-propelled vehicles (i.e., the engine that provides the motive power). The engine is the power source to move the off-road vehicle, but the same engine may also be used to power equipment mounted onto or attached to the vehicle through a power-take off (PTO) or through hydraulics. Although the terms "vehicle", "machines", and "equipment" are often used to describe these type of machinery, in this regulation the term "vehicle" is used. This is to distinguish from equipment that the ARB defines as portable equipment, such as engines powering equipment mounted on trailers or on trucks, and subject to other regulations. Please refer to Chapter VII- "Proposed Regulation", which covers in more detail which vehicle types would be subject to the requirements of this regulation.

B. Vehicle Manufacturers

There are hundreds of vehicle manufacturers of off-road vehicles subject to the proposed regulation. A number of vehicle manufacturers also manufacture engines for their equipment, but most vehicle manufacturers design vehicles to accept engines manufactured by other companies. Table V-1 lists only a small sample of common vehicle manufacturer names to illustrate the diversity of the vehicles manufactured in this sector.

Table V-1 - Common Manufacturers of Off-Road Vehicles

Allmand	Eagle	Harlan	Mitsubishi
ASV	Ford	Hitachi	Mustang
Badger	FMC	Hyundai	New Holland
Blaw-Knox	Gehl	Iveco	Sennebogen
Bobcat	Genie	Kawasaki	Shuttle Lift
Broderson	Grove	Kobelco	Terex
Case	GMC	Komatsu Kubota	Terramite
Caterpillar	JCB	Liebherr	Tug
Clark	JLG	Lift Systems	Vermeer
Daewoo	Ingersoll Rand	Link-Belt	Volvo
Ditch Witch	John Deere	Manitowoc	

Some engine manufacturers also supply engines for multiple equipment manufacturers, while some manufacture engines exclusively for their own vehicle product line. Table V-2 lists the manufacturers of off-road engines commonly used in off-road vehicles.

Table V-2 - Manufacturers of Off-Road Engines

Detroit Diesel	John Deere
Caterpillar	Komatsu
Cummins	Kubota
Daimler	Mitsubishi
Deutz	Nissan
Ford	Perkins
General Motors	Volvo
International	Yanmar
Iveco	

C. Vehicle Types

There are thousands of vehicle models subject to the proposed regulation. The following section provides an overview of a number of common vehicle types affected. The examples described were chosen to illustrate fairly common types of vehicles in each of the sectors subject to the regulation. Information regarding the population of various vehicle types in California is identified in Chapter VI.

1. Dozer

The term dozer (or bulldozer) refers to an off-road tractor, either tracked or wheeled, equipped with a blade. In the emissions inventory, dozers are called “crawler tractors.” A ripper, which is a claw-like device, may be attached to the back of a larger dozer (typically greater than 200 hp). The ripper is useful in loosening up the ground so that the blade will be able to penetrate and fill

Dozer

quickly. Dozers range in size from 77 hp to 900 hp, with most being between 300 hp to 400 hp. Dozers are used in a wide variety of industries such as construction and mining for earthwork and grading to move piles of dirt, also in construction for demolition, and industrial settings to position bulk cargo.

2. Loaders

The term “loader” is generic, and can be any type of off-road tractor that uses a bucket on the end of movable arms to lift materials into trucks, and move material such as dirt, debris, building materials, bulk goods, heavy objects, or snow removal. Loaders are used widely in construction, mining, industrial sectors and road maintenance. There are many different types of loaders, including but not limited to, front end, skid steer, backhoe, rubber tired, and crawler.

Loader

Loaders are manufactured in a wide range of sizes, from 36 hp (for small, skid steer loaders) to over 1,000 hp (for large, rubber-tired loaders), with most being between 200 hp and 750 hp. Small loaders may have bucket capacities of one cubic yard or less, while the large rubber-tired loaders can have a bucket capacity over 45 cubic yards.

Backhoe Loader

Backhoe loaders are a very common and relatively small tractor with a rear arm attachment designed to dig narrow trenches much like an excavator. A common application for a backhoe loader is for street work, where the narrow backhoe bucket can excavate a trench for piping or wiring conduit.

Skid Steer

Skid steer tractors are very compact and maneuverable. They are used in tight spaces, for example they are utilized to excavate swimming pools and in landscaping residential backyards. Most tractors have different attachments to perform multiple functions. Skid steers in particular are quite versatile and can be equipped with a variety of attachments, such as a hammer, augur, trencher, forklift and other attachments.

3. Forklifts

Forklifts are industrial trucks used to hoist and transport materials by means of one or more steel forks inserted under the load. Forklifts are extremely diverse in both their size and custom cargo handling abilities. Forklift engines can be powered by internal combustion engines, such as compression ignition (i.e., diesel or natural gas) or spark ignition (i.e., gasoline or propane) engines, or electric motors. Compression ignition forklifts are usually designed for higher lift capacity than their electric or spark ignited counterparts. The majority of forklifts powered by diesel engines have a horsepower range of about 45 hp to 200 hp, although some have engines over 200 hp. Forklifts are available for both indoor and outdoor applications and can have a load capacity of 3,000 lbs to 30,000 lbs or more. Diesel forklifts tend to have lift capacities over 6,000 lbs, and they are usually used outdoors and thus have pneumatic tires. Forklifts are used in a variety of applications, including, but not limited to, manufacturing, construction, retail, meat and poultry processing, lumber and building supplies, trades, agriculture, and a variety of warehouse operations.

Telescopic Forklift

Mast Forklift

There are seven different classes associated with forklifts. Classes I through III are electric-powered, and Classes IV through VII are powered by internal combustion engines. Class VII is labeled as Rough Terrain, and includes both straight-mast forklifts and extended-reach forklift (telescopic, also called telehandlers).

4. Aerial Lifts

Aerial lifts are similar to forklifts, with the significant difference being that aerial lifts are designed to lift a person or persons. They are commonly used in construction and in maintenance operations. The controls to move the bucket or work platform are located at the bucket or platform. The main configurations are boom, telescopic and scissor lift. The engines for these lifts can be powered by either internal combustion engines, such as compression ignition (i.e., diesel or natural gas) or spark ignition (i.e., gasoline or propane) engines, or electric motors.

Aerial Lift

5. Motor Graders

Motor graders are used to establish a rough or finish grade, spread material for building paved roads, build and maintain unpaved roads, such as rural or mine haul roads, and clear snow from roads. Motor graders contain engines with horsepower typically between 125 to 500 horse power, and blade widths range from 12 to 24 feet.

Motor Grader

6. Cranes

There are a considerably wide variety of cranes that range widely in size, weight and function. Cranes are used to both to lift and lower materials, and to move them horizontally. Large cranes are commonly used in the construction of buildings, bridges, and in manufacturing. Smaller cranes are used in a variety of application across many sectors. Cranes may have a telescoping, lattice or articulating (folding) booms. The capacity rating is in tons that the crane can safely lift. The smaller cranes may have engines with less than 25 hp, while some contain engines over 500 hp. Some of the largest cranes will have two engines, an upper and lower engine. In these cranes, the lower engine propels the vehicle to position itself and the upper engine provides the power for performing the lifting or dragging function once in position. Smaller cranes only have one engine which is used to propel the vehicle and to provide the lifting power.

Carry Deck Crane

The most common type of large crane, a truck crane, is designed to be licensed and driven on the highway from site to site. These cranes represent a vast majority of the larger cranes operating in California, but since they are not off-road vehicles, they would not be subject to the proposed regulation. However, similar large cranes that are designed to operate off-road and cannot be driven safely on the road because of their size, weight or configuration would be subject to the regulation. These include rough terrain, all terrain, crawler and carry deck cranes. Only the engine that provides the motive power for the crane is subject to this regulation. For the fairly uncommon off-road crane with two engines (an upper and a lower) only the lower engine is considered in the scope of this regulation.

Crawler Dragline Crane

7. Scrapers

Formally named wheel tractor-scraper, this large machine is used for earthmoving and mining. The rear section has a vertically moveable hopper with a sharp horizontal front edge. The hopper can be hydraulically lowered and raised. When the hopper is

Scraper

lowered, the front edge cuts into the soil and fills the hopper. The engines have horsepower ranging from 175 to over 500 hp. The heavier scraper types have two engines ('tandem powered').

8. Airport Ground Support Equipment

Aircraft Pushback Tractor

Airport vehicles and ground support equipment (GSE) are used to transport passengers as well as baggage and freight, tow aircraft, support maintenance and repair functions, and provide power to various service functions. Aircraft pushback tractors are used to push aircraft back from the gate. Baggage tugs are used to transport baggage to and from aircraft. Cargo loaders are used to load and unload cargo to and from aircraft. Belt loaders are used to load and unload baggage to and from aircraft.

Cargo Loader

Vehicles and equipment at airports fall into two broad categories: land-side vehicles and equipment are used on the passenger/entry side of the airport, and air-side vehicles are used principally on the tarmac. Most land-side vehicles would not be subject to this regulation, as they are typically on-road vehicles, while a majority, (but not all) of the air-side diesel powered vehicles would be. Airport GSE includes aircraft pushback tractors, baggage and cargo tugs, forklifts and lifts, belt loaders, and other equipment.

Airport GSE are somewhat unique vehicles and, in California, utilize a variety of fuel types including gasoline, diesel, electric and alternative fuels. Internal combustion engines are the most common. Electric GSE is commercially available from a number of manufacturers, and interest in the use of electric equipment at airports is increasing. About 20 percent of the statewide GSE used at airports in California are already electric, with the largest proportion at southern California airports.

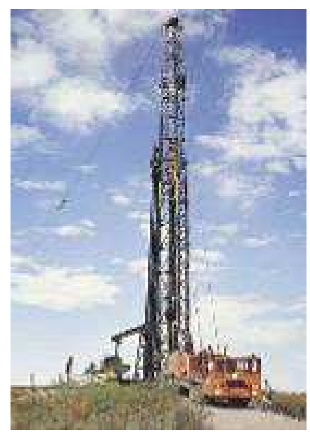
Belt Loader

Airport GSE are powered by engines with horsepower ranging from 50 to 500. The smaller vehicles such as belt and cargo loaders and lifts contain the lower horsepower engines, while some of the largest GSE are the wide body aircraft tugs which may have engines with 500 horsepower. The most common equipment types which would be subject to this regulation are: baggage tugs, cargo loaders, belt loaders, and aircraft pushback tractors.

9. Drilling

Crawler Drill

Drill rigs may be categorized into vertical and directional. They are used to drill wells (i.e., for oil or water), for building construction and to drill holes for inserting explosive charges to clear rock for construction or mining. They may utilize tires or crawler treads depending upon the design and function. They range in size and capability with engines from 25 to over 400 hp. Drill rigs are also often truck mounted to facilitate movement from site to site. However, truck mounted mobile drill rigs which are legally capable of being driven on the roadways are classified as on-road, and therefore not subject to the requirements of this regulation.



Workover Rig

Workover rigs are mobile self-propelled rigs used to perform one or more remedial operations on a well. These operations include deepening, plugging back, or pulling and resetting liners, usually on a producing oil or gas well to try to restore or increase the well's production. Workover rigs are very similar to drill rigs in that they are truck-mounted mobile rigs that travel between job sites on public roads. However, these machines are generally located at the job site for weeks before relocating to a different location. Because of the predominant proportion of work done off-road, workover rigs are explicitly included in the scope of the regulation although they can be registered for on-road use.

D. Affected Industries and Businesses

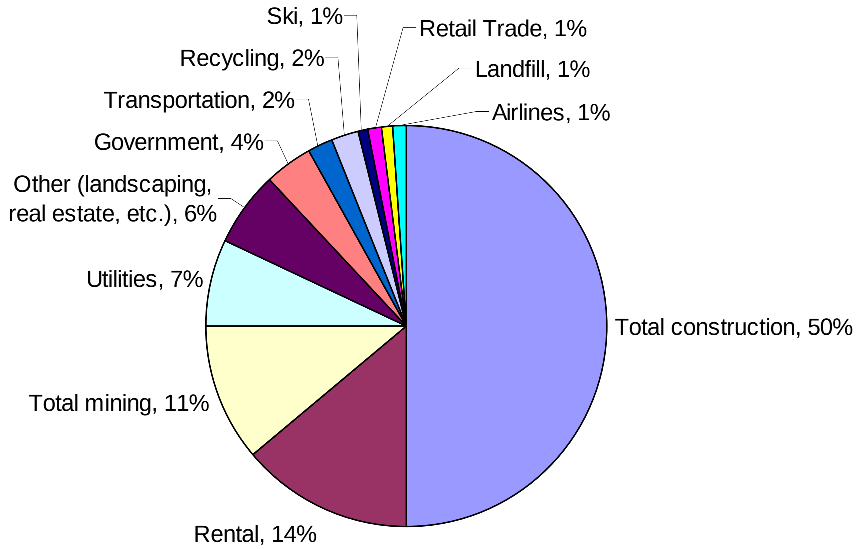
Construction vehicles make up roughly half of the vehicles affected by this regulation. A wide variety of construction vehicles, commonly ranging from 25 hp to 600 hp, are utilized during the various stages of different construction projects, which include tasks such as demolition, grubbing and clearing, dewatering, earthwork (excavation), grading, paving/surfacing, foundation work, building erection and other infrastructure developments. Vehicles used in construction range from production machines, that have high utilization and are the primary source of income, to support vehicles that are not heavily utilized but are necessary to perform the project. Construction businesses range from owner operators and independent small contractor businesses with one vehicle, to extremely large fleets with hundreds of vehicles and thousands of employees. Often these larger fleets utilize smaller subcontractors who most commonly perform somewhat specialized work to support large projects led by larger contractors.

The mining category represents about 1,000 active mines in California. The common type of mining performed is open pit mining, which has activities similar to the earthwork and grading aspects of construction. Vehicles used in open pit mining typically range from smaller vehicles to the largest vehicles manufactured. The largest vehicles typically have horsepower ranging from about 500 horsepower to several thousand horsepower, and include trucks, loaders, and heavy shovels. Smaller vehicles such as loaders, graders and drill rigs range from 150 hp to 500 hp, and provide support and production functions. Mines often also have a small number of small support vehicles. Mine operations range from fleets with a handful of vehicles at a single mine with dozens of employees operating a single shift, to those operating hundreds of vehicles and having hundreds of employees at numerous mines throughout the state, operating around the clock.

The industrial sector includes thousands of manufacturing facilities and wholesale and retail distribution points throughout the state where forklifts, cranes and other tractors are used to facilitate manufacturing and to distribute raw materials and finished product. This sector includes a wide variety of business types including, ski resorts, recycling facilities, landfills, refineries, power plants, retail goods, wholesale good, utility services, golf courses, sewage treatment plants, landscape materials, rental yards and hundreds of other business types.

As part of the data collection to support this regulation, the ARB performed a survey of construction, mining and industrial businesses, and data on nearly 10,000 vehicles were obtained (ARB, 2006). The types of business that responded to the survey, and the percentage of vehicles reported by types of businesses, are represented below in Figure V-1.

Figure V-1 - Vehicle Population Reported in ARB 2005 Survey



Within each of the three off-road vehicle categories (Construction, Mining and Industrial), there are nearly an unlimited number of vehicle horsepower combinations that could make up various fleets.

A smaller fleet may be a company that has a single loader for moving bulk goods onto on-road trucks, or a forklift for industrial operations, or a landscaping company with a backhoe loader, a skid steer, and a few ride-on lawn mowers, or a small construction company that owns their own backhoe loader, a telehandler, and a mini-excavator, and rents other pieces on an as needed basis. A pool construction company may own a few small skid steers that use attachments to both break up concrete, and a bucket to load the broken concrete and dirt into a truck, with a loader at the yard to load dirt.

Companies with 1,501 to 5,000 hp may include:

- construction companies who provide sub-contactor services for major construction sites such as paving, excavation and grading, and demolition;
- commercial or industrial sites;
- independent landfill operations;
- city road maintenance fleets (pot hole repairs, landscaping and chip seal roads);
- larger bulk goods yards and relatively small equipment rental companies.

Fleets of this size may also include companies that operate airport ground support equipment, mines, and other public agencies such as water or sewer districts that install or repair pipelines, or operate larger facilities such as waste water treatment plants and storm drains systems.

Companies with more than 5,000 horsepower in their fleets are typically large construction companies, large city, county and state agencies, larger mines, and large distribution companies.

E. New Engine Standards

New off-road engine standards, adopted by both U.S. EPA and ARB, have required new off-road engines to become progressively cleaner since the mid 1990's. Because of the increasingly stringent standards and advancements that have been made in combustion technology and engine design, Tier 3 diesel engines today emit over 60 percent less NOx and PM than Tier 0 engines (Diesel, 2005), with further reductions expected due to Tier 4 standards. This section discusses the changes in technologies that were used to meet the Tier 1 through 3 standards and those expected to be used to meet the interim and final Tier 4 standards.

a) ARB and U.S. EPA Standards

The ARB has the authority to regulate engines in new off-road equipment equal to or greater than 175 hp and non-preempted off-road equipment less than 175 hp. ARB and U.S. EPA have worked closely to harmonize the off-road compression ignition (CI) engine standards. ARB is preempted from regulating new farm and construction equipment less than 175 hp as the U.S. EPA has sole authority to regulate this type of equipment. However, ARB is not preempted from regulating in-use equipment regardless of engine horsepower.

Emissions from engines utilized in off-road equipment between 175 and 750 horsepower were uncontrolled prior to 1996. Estimates of NOx emission rates from uncontrolled off-road engines range from 8.2 grams per brake horsepower-hour (g/bhp-hr) to 14 g/bhp-hr. In January 1992, the Board adopted exhaust emission standards for off-road diesel-cycle engines 175 hp and greater, effective beginning with 1996 model year engines.

In August 1996, U.S. EPA, ARB, and off-road diesel engine manufacturers signed a Statement of Principles which called for harmonization of ARB and U.S. EPA off-road diesel engine regulations, as appropriate, in exchange for an accelerated introduction of progressively more stringent standards. The U.S. EPA adopted emission standards in 1998 and again in 2004 that provided for new NOx plus non-methane hydrocarbons (NMHC), PM, and CO emission standards for engines within different power categories in a tiered approach, commonly referred to as "Tier" standards. In California, these standards, which are harmonized with the U.S. EPA, are contained in Title 13, California Code of Regulations (CCR), sections 2423(b)(1). Table V-3 summarizes the emission standards for these engines.

Table V-3 - ARB and U.S. EPA Off-Road Compression-Ignition (Diesel) Standards (NMHC+NOx/CO/PM in g/bhp-hr where applicable)

HP (kW)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015+
< 11 (8)	See Table 2 footnote (a)					7.8 / 6.0 / 0.75 (10.5 / 8.0 / 1.0)					5.6 / 6.0 / 0.60 (7.5 / 8.0 / 0.80)			5.6 / 6.0 / 0.30[a] (7.5 / 8.0 / 0.40)							
≥ 11 (8) < 25 (19)						7.1 / 4.9 / 0.6 (9.5 / 6.6 / 0.80)					5.6 / 4.9 / 0.60 (7.5 / 6.6 / 0.80)			5.6 / 4.9 / 0.30 (7.5 / 6.6 / 0.40)							
≥ 25 (19) < 50 (37)	-				7.1 / 4.1 / 0.60 (9.5 / 5.5 / 0.80)					5.6 / 4.1 / 0.45 (7.5 / 5.5 / 0.60)				5.6 / 4.1 / 0.22 (7.5 / 5.5 / 0.30)					3.5 / 4.1 / 0.02 (4.7 / 5.5 / 0.03)		
≥ 50 (37) < 75 (56)	-			- / 6.9 / - / -[b] (- / 9.2 / - / -)						5.6 / 3.7 / 0.30 (7.5 / 5.0 / 0.40)				3.5 / 3.7 / 0.22[c] (4.7 / 5.0 / 0.30)					3.5 / 3.7 / 0.02[c] (4.7 / 5.0 / 0.03)		
≥ 75 (56) < 100 (75)	-													3.5 / 3.7 / 0.30 (4.7 / 5.0 / 0.40)				0.14/ 2.5/ 3.7/ 0.01[b,d] (0.19/ 3.4 / 5.0 /0.02)			0.14 (0.19) 0.30 (0.40) 3.7 (5.0) 0.01[b] (0.02)
≥ 100 (75) < 175 (130)	-								4.9 / 3.7 / 0.22 (6.6 / 5.0 / 0.30)				3.0 / 3.7 / 0.22 (4.0 / 5.0 / 0.30)								
≥ 175 (130) < 300 (225)	-	1.0 / 6.9 / 8.5 / 0.40[b] (1.3 / 9.2 / 11.4 / 0.54)							4.9 / 2.6 / 0.15 (6.6 / 3.5 / 0.20)			3.0 / 2.6 / 0.15[e] (4.0 / 3.5 / 0.20)					0.14 / 1.5 / 2.6 / 0.01[b,d] (0.19/ 2.0 / 3.5 /0.02)			0.14 (0.19) 0.30 (0.40) 2.6 (3.5) 0.01[b] (0.02)	
≥ 300 (225) < 600 (450)						4.8 / 2.6 / 0.15 (6.4 / 3.5 / 0.20)															
≥ 600 (450) ≤ 750 (560)																					
Mobile Machines > 750 (560)	-					1.0 / 6.9 / 8.5 / 0.40[b] (1.3 / 9.2 / 11.4 / 0.54)						4.8 / 2.6 / 0.15 (6.4 / 3.5 / 0.20)					0.30 / 2.6 / 2.6 / 0.07[b] (0.40 / 3.5 / 3.5 / 0.10)				0.14 (0.19) 2.6 (3.5) 2.6 (3.5) 0.03[b] (0.04)
GEN >750 (560) ≤1207 (900)																					0.14 (0.19) 0.50 (0.67) 2.6 (3.5) 0.02[b] (0.03)
GEN>1207 (900)																	0.30 / 0.50 / 2.6 / 0.07[b] (0.40 / 0.67 / 3.5 / 0.10)				

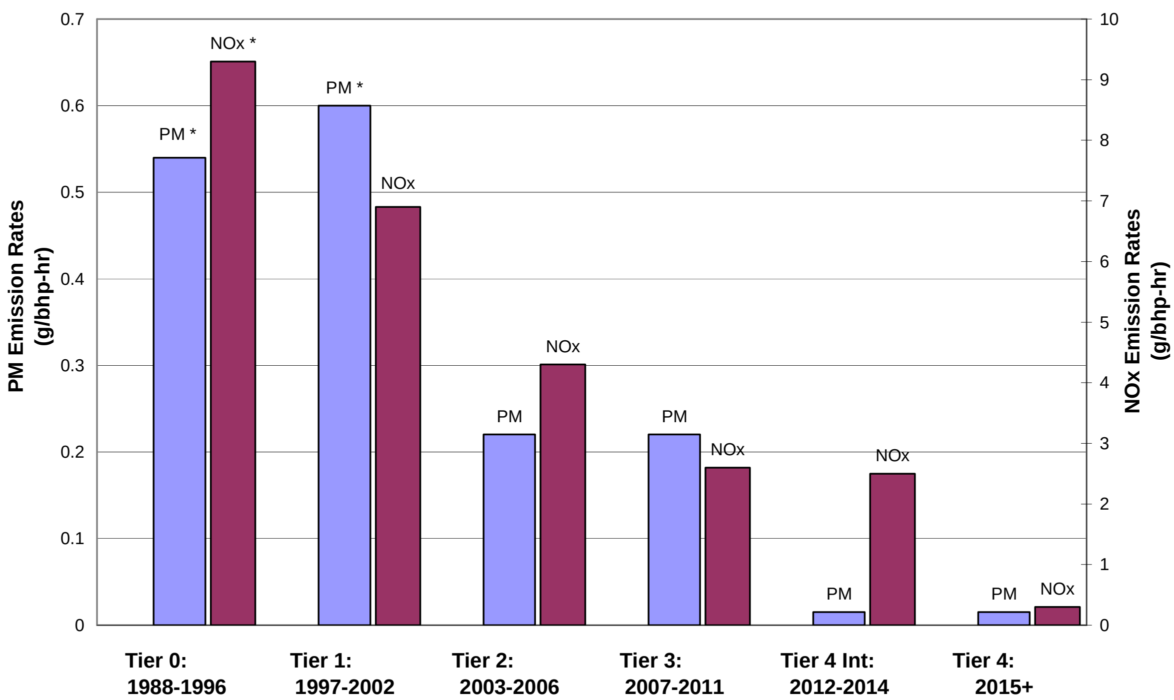
a) The PM standard for hand-start, air cooled, direct injection engines below 11 hp (8 kW) may be delayed until 2010 and be set at 0.45 g/bhp-hr (0.60 g/kW-hr).
b) Standards given are NMHC/NOx/CO/PM in g/bhp-hr (or g/kW-hr).
c) Engine families in this power category may alternately meet Tier 3 PM standards [0.30 g/bhp-hr (0.40 g/kW-hr)] in 2008-2011 in exchange for introducing final PM standards in 2012.
d) The implementation schedule shown is the three-year alternate NOx approach. Other schedules are available.
e) Certain manufacturers have agreed to comply with these standards by 2005.

: Tier 1 : Tier 2 : Tier 3 : Tier 4 Interim / Final

The off-road engine emission standards are tiered (i.e., Tier 1, 2, 3, 4), and the date upon which each tier takes effect depends on the engine horsepower (size). As of January 1, 2000, all engine sizes were subject to Tier 1 standards. In 2006, all engine sizes were subject to Tier 2, while some Tier 3 standards also took effect (engines less than 75 horsepower or greater than 750 horsepower do not have a Tier 3 standard). Tier 4 standards are divided into two stages: interim, which begins between 2008 and 2012 for most engines, and final, which is effective for all off-road engines by 2015. The final Tier 4 standards will result in diesel engines that will be over 90 percent cleaner than 1988 vintage engines. The Tier 4 standards require most engines to meet a 0.01 g/bhp-hr diesel PM emission rate and a 0.3 to 0.5 g/bhp-hr NOx emission rate in the 2011-2015 timeframe. While staff has worked closely with U.S. EPA to develop a harmonized federal and California program to more effectively control emissions from off-road equipment, when it has been feasible to do so the Board has adopted a more stringent program than the federal program and adopted engine test procedures that more accurately measure emissions that occur during typical in-use operating conditions.

In general, manufacturers of new off-road compression-ignition engines have been employing emission control strategies and technologies similar to those already in use by the manufacturers of new on-road compression-ignition engines. This trend is expected to continue. The effectiveness of these controls could vary because of the different operating environment experienced by off-road engines. Although on-road and off-road engines alike experience frequent load and speed changes, the exhaust temperature of an off-road engine is generally lower than an on-road engine and therefore may not be as amenable to temperature-sensitive exhaust retrofits. Another important consideration is that the same off-road engine may be used in a variety of applications; this can complicate the application of some strategies due to different packaging constraints. Retrofit emission control devices for in-use engines (those not installed by the engine manufacturer) are discussed in Chapter VIII – Technological Feasibility. Figure V-2 illustrates diesel PM and NOx emission rates between the various model years, and engine tiers.

Figure V-2 - ARB and U.S. EPA Diesel PM and NOx Emission Standards for New Off-road Engines 100 to 174 Horsepower



* - Estimated emission rate is shown because standards did not exist for this pollutant at that time.

b) Technology Used to Meet Standards

In order to meet these increasingly stringent exhaust emission standards, manufacturers of new off-road compression-ignition engines have employed a wide variety of emission control strategies and technologies. Since the 1970's, much of the diesel engine emission control has been achieved through emission-conscious engine design. For example, emission improvements have included modifications in combustion chamber geometry, design for better fuel atomization and mixing with the air, and increased fuel injection pressure (DieselNet, 2003). Older engines had mechanically-controlled injection timing. Since the early to mid-1990's, most diesel off-road engines have been electronically controlled. This provides precise fuel metering (including multiple injection bursts during the combustion cycle) and very high injection pressures which improve performance and lower emissions. In the past 15 years, more development effort has been put into catalytic exhaust emission control devices for diesel engines, especially in the areas of particulate matter (PM) control. These developments have made the widespread commercial use of diesel exhaust emission controls feasible (ARB, 2003).

The emission tier standards, and the controls utilized to meet the increasingly lower emissions levels, are discussed below.

(1) Tier 1 Standards

In 1992, the Board approved standards for off-road diesel engines 175 hp and greater (ARB, 1999). These standards, which were implemented beginning in 1996, targeted NOx emission reductions without an increase in NMHC or PM emissions. The 175 hp boundary was chosen to avoid preemption issues in the implementation of the regulation rather than for technical or cost-effectiveness reasons. The goal of these initial off-road diesel engine standards was to reduce emissions using the most feasible control technologies that would not require a need to change the packaging (shape) of the engine. The majority of engine modifications that were made to comply with the Tier 1 standards were fuel injector and fuel injection timing changes, combustion chamber enhancements, and the incorporation of engine after-coolers. Tier 1 has resulted in approximately a 50 percent drop in NOx emissions compared to previously uncontrolled off-road diesel engines of similar power. Following ARB's adoption of initial standards, U.S. EPA promulgated a substantially similar program for engines 37 kW (~50hp) and greater.

(2) Tier 2 Standards

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

(3) Tier 3 Standards

Tier 3 off-road diesel standards took effect in 2006 and are applicable to engines from 75 to 750 hp. The new standards reduced NMHC+NOx emissions for most power categories by an additional 40 percent compared to Tier 2 standards. However, Tier 3 standards do not reduce PM emission levels beyond existing Tier 2 levels. The control technologies that engine manufacturers are using to comply with the Tier 3 requirements are enhanced combustion techniques, including variable-timing overhead valve configurations, higher pressure fuel injection, electronic engine management systems, and to a lesser extent exhaust gas recirculation (EGR) and lean burn catalysts.

(4) Tier 4 standards

As was the case for previous tiered engines, manufacturers of off-road diesel engines are expected to use emission controls similar to those already in use or planned for use by the manufacturers of on-road diesel engines, although effectiveness to reduce emissions could vary due to the different operating conditions experienced by off-road engines and the wide variety of applications.

Engine manufacturers are likely to need PM and NOx exhaust aftertreatment to achieve final Tier 4 standards. Likely the most challenging consideration in transferring advanced emission control technologies to the off-road will be exhaust temperature (ARB, 2004). Exhaust temperature is critical for the regeneration of catalyzed exhaust emission control devices.

In general, exhaust temperature increases with engine power and can vary dramatically as engine power demands vary. For catalyzed diesel particulate filters (CDPFs), exhaust temperature determines the rate of filter regeneration. CDPF controls PM emissions under all conditions and can function properly even when exhaust temperatures are low for an extended period of time. This is acceptable to a CDPF if the regeneration rate is lower than the soot accumulation rate, provided that occasionally exhaust temperatures, and the soot regeneration rate, are increased enough to regenerate the CDPF. To achieve this, the engine must typically be operated under conditions that would ensure sufficient exhaust temperature long enough to regenerate the CDPF.

Exhaust aftertreatment systems that reduce NOx emissions will also be needed to meet future engine standards. The more promising high efficiency NOx control systems such as selective catalytic reduction and NOx adsorbers, generally need to operate in temperature regimes similar to those required for passive DPF systems. Selective catalytic reduction (SCR) systems inject ammonia or urea into the diesel exhaust stream which then reacts over the catalyst bed with the NOx in the exhaust to produce water and nitrogen, thus reducing the diesel exhaust NOx. For NOx adsorbers, there is a minimum temperature (e.g., 200℃elsius) below wh ich regeneration is not readily feasible, and a maximum temperature (e.g., 500℃el sius) above which NOx adsorbers are unable to effectively store NOx. Therefore, there is a need to match diesel exhaust temperatures to conditions for effective catalyst operation under the various operating conditions of off-road engines. Most manufacturers are developing systems for on-road exhaust systems prior to developing those for off-road, because on-road engine standards become more stringent sooner than for off-road applications.

U.S. EPA has conducted an analysis of various operating cycles and various engine power density levels to better understand the matching of off-road engine exhaust temperatures, catalyst installation locations, and catalyst technologies. This study, documented in U.S. EPA's Regulatory Impact Analysis (U. S. EPA, 2000), shows that for many engine power density levels and equipment operating cycles, exhaust temperatures are matched quite well to catalyst temperature window characteristics, and exhaust aftertreatment systems are feasible.

Still, some off-road engines may experience in-use conditions requiring the use of temperature management strategies (e.g., active regeneration) to effectively use NOx adsorber and CDPF systems. Based on U.S. EPA's analyses, staff does not believe that there are any off-road engine applications above 25 hp for which active temperature management will not work.

c) Averaging and Flexibility Provisions

To provide flexibility to off-road engine manufacturers, the Tier 2, 3, and interim and final Tier 4 standards all contain averaging and flexibility provisions that mean that some engines that legally comply with the standards do not actually emit at the relevant tier levels.

(1) Tier 2 and Tier 3 Standards

Regulations for Tier 2 and Tier 3 standards for off-road heavy-duty CI engines contain a flexibility provision that allows original equipment manufacturers (OEMs) to include some engines not meeting current applicable emission standards in their existing product line for new equipment. Therefore, these engines may emit more emissions than other new engines certified to the same engine Tier. The flexibility provision was effective with the introduction of Tier 2 engines (Tier 1 for power categories less than 50 hp), and applies separately for each engine power category. Engine families certified under the flexibility provision must have previously been certified to a prior engine standard, for example Tier 1.

There are four main elements to the flexibility program: 1) a percent-of-production allowance, 2) a small-volume allowance, 3) continuance of the Tier 1 allowance to use up existing inventories of engines, and 4) availability of hardship relief. The percent-of-production allowance is the largest component of the program, and allows each equipment manufacturer to use flexibility engines in its new product line over a seven-year period in cumulative quantities that sum up to 80 percent of a single year's national production at the end of the seven years.

Except for engines used in flexibility allowances prior to January 1, 2007, flexibility engines greater than 175 hp certified for sale in California must be labeled according to the requirements of Title 13, CCR, sections 2423(d) and 2424(c). In addition, the Executive Order (EO) for engines certified under this program state that the engines were certified in compliance with Title 13, CCR, section 2423(d).

Off-road engine manufacturers are also allowed the option to participate in an Averaging, Banking, and Trading (ABT) program in lieu of only producing engines that comply with the current emission standards. The emission benefits from an engine certified to a lower Family Emission Limit (FEL) may be used to offset the emissions from engines certified to a higher FEL levels within the engine manufacturer's ABT program. As a result, ABT emission credits are generated from the lower FEL level engine since it is certified lower than the required emission standards. Overall the entire engine family meets the emission standards.

(2) Tier 4 Standards

The adoption of the Tier 4 emission standards added several additional components to the program including technical hardship allowances, retroactive use of flexibilities, delayed implementation, an economic hardship allowance, an early introduction incentive, and a labeling requirement.

(a) Phase-in and Interim Standards

The Tier 4 standards are phased in beginning in 2008 for 25-74 hp engines, and in 2011 or 2012 for larger engines. Tier 4 contains interim standards with higher PM and NOx or NMHC+NOx levels for 25-74 hp and >750 hp engines for the years up to 2012-2014, after which the final Tier 4 standards take effect. For the power categories 75-750 hp (56-560 kW), aftertreatment based NOx standards are phased in the years 2011-2014. In these years, a significant percentage of engines can be "Tier 3 phase-out engines," i.e., engines that meet the Tier 3, but not the Tier 4, NOx standard. For 56-130 kW engines, for example, 75 percent of engines produced in 2012-14 can be "Tier 3 phase-out" engines. As an alternative to using the Tier 3 phase-out provisions described above, for 75-750 hp engines, manufacturers may also meet an "alternate NOx standard" which is higher than the Tier 4 standard during the phase-in period.

(b) Final Tier 4 Standards

As summarized below, there are a number of provisions in the Tier 4 standards that provide that some engines with emissions not meeting the final Tier 4 standards may still be sold, even after the final Tier 4 standards take effect.

<u>Averaging, Banking, and Trading</u> (AB&T) – Manufacturers certify their engines to family emission limits (FELs) that may be greater than or less than the standard. The FELs may be any value up to a maximum FEL cap. Manufacturers get credit for engines certified to FELs below the standard and negative credits for those certified to FELs above the standard and have to balance to zero. They can also sell credits

or buy credits from other manufacturers. So, those engines that are certified to an FEL above the standard will be compliant even though they do not meet the Tier 4 standard emission limits.

Percent of Production Allowances – Once Tier 4 standards take effect, for each of the five power categories covered by Tier 4, equipment manufacturers are permitted to install previously certified engines (“flexibility engines”) in equipment adding up to 80 percent of one year’s national equipment production spread out over a period of seven years. The flexibility engines will be labeled, along with the engine family, so they can be differentiated from true Tier 4 engines.

Existing Inventory Allowance – Equipment manufacturers may continue using engines built prior to the effective date of the Tier 4 standards until their supply is exhausted.

Other Allowances – There are special provisions for small volume manufacturers that will allow them to each produce hundreds of additional “flexibility engines.” Equipment manufacturers may also petition to produce additional “flexibility engines” (to 70 percent of one year’s national equipment production) for additional relief on the basis of technical hardships. Equipment manufacturers may also apply for additional relief if they are facing economic hardship.

Early Introduction Incentives – Engine and equipment manufacturers can earn additional allowances for more “flexibility engines” if they produce and sell some Tier 4 engines prior to 2011 in exchange for making fewer Tier 4 engines after 2011 (i.e., produce 1 compliant engine early, then produce 1.5 less compliant engines later). These engines must meet all federal labeling requirements, but must add the following additional statement: “This engine meets U.S. EPA emission standards under 40 CFR 1039.104(a)” and an additional statement of “meeting ARB requirements under 13 CCR section 2423(b)(6)”. In addition, the EO for engines certified under this program will reference that the engines were certified in compliance with 13 CCR section 2423(b)(6).

In-use Compliance Margins – In the early years of the Tier 4 standards, an error margin is added to the certification standards so that engine manufacturers will not face recall if they exceed the certification standards by a small amount during in-use testing.

(3) On-Road Engines

Historically, on-road engines certify to standards several years earlier than similar standards required for off-road engines. On-road engines are currently available for a few types of vehicles that are subject to this rule. On-road engine standards began with the 1974 model year and are lower than those for similar off-road engines. New standards effective with the 2007 model year on-road engines will necessitate the use of PM exhaust aftertreatment technologies for all classes of heavy-duty diesel engines and vehicles (ARB, 2001). Overall, these standards 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 engines are available today. These emission standards are also applicable to both natural gas-fueled engines and liquefied petroleum gas-fueled engines derived from the diesel cycle engine. The engine standards phase in the final 2010 NOx and hydrocarbon emissions standard between 2007 and 2010. The phase-in schedules, shown in Table V-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 2009 model year.

Table V-4 - Exhaust Emission Standards and Phase-In Schedule for 2007 and Later Model Year Heavy-Duty Diesel On-Road Engines

Pollutant	Standard (g/bhp-hr)	Phase-In by Model Year[11]			
		2007	2008	2009	2010+
NOx	0.20	50%	50%	50%	100%
NMHC	0.14	50%	50%	50%	100%
PM	0.01	100%	100%	100%	100%

Test methods used to certify on-road engines are different than those for off-road engines. On-road engine certification methods require a transient duty cycle, while the off-road engine certification methods use a steady state duty cycle. Recent testing shows that on-road engines will reduce emissions even when used for off-road purposes. In support of the ARB's regulations for mobile cargo handling equipment at ports and intermodal rail yards, in 2004, staff conducted testing, in partnership with the Port of Los Angeles and through the University of Riverside, of yard trucks equipped with on-road diesel engines, using an off-road duty cycle. The emission rates from the off-road duty cycle were compared to the U.S. EPA certified on-highway, transient emission rates for the engine family. The comparison indicated the on-road engine's emission rates were similar over both duty cycles, indicating that the off-road duty cycle did not increase the on-road engine's emissions. Based on these results, staff believes that similar results would be observed for future model year on-road engines as well.

For some off-road equipment covered by this proposed regulation, the manufacturer provides the option of powering the equipment by either an off-road or on-road certified engine. The purchaser of the equipment makes that choice depending on a variety of factors. Except in rare cases, equipment powered by an off-road engine is not allowed to operate more than incidentally of public roadways.

Fleets that have off-road vehicles with on-road certified engines would be able to use the on-road engine standards instead of the off-road engine standards for determining compliance with the proposed rule. Also, in limited applications, new on-road engines may be a viable repower strategy for some off-road vehicles of similar horsepower and

[11] Percent of sales.

operational characteristics as on-road trucks. The following table shows the on-road engine certification standards.

Table V-5 - On-Road Heavy-Duty Diesel Engine Standards (g/bhp-hr)

Engine Model Year	NOx	PM
Pre-1979	--[12]	Use Off-Road[12]
1979	7.5	Use Off-Road[12]
1980	5.2	Use Off-Road[12]
1985	5.1	Use Off-Road[12]
1987	6.0	0.60
1991	5.0	0.25
1994	5.0	0.10
1998	4.0	0.10
2004	Use actual certification standard[13]	0.10
2007+	Use actual certification standard[13]	0.01

F. References

ARB, 1999. California Air Resources Board*. Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Amendments To Off-Road Compression Ignition Engine Regulations: 2000 And Later Emission Standards, Compliance Requirements And Test Procedures*; December 10, 1999.

ARB, 2001. California Air Resources Board*. Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Amendments Adopting More Stringent Emission Standards For 2007 And Subsequent Model Year New Heavy-Duty Diesel Engines*; September 7, 2001.

ARB, 2003. California Air Resources Board. *Staff Report: Technical Support Document, Proposed Control Measure for Diesel Particulate Matter from On –Road Heavy-Duty Diesel-Fueled Residential and Commercial Solid Waste Collection Vehicle Diesel Engines*; August 8, 2003.

ARB, 2004. California Air Resources Board. *Staff Report: Staff Report: Initial Statement of Reasons for Proposed Rulemaking; Public Hearing to Consider Amendments To The*

[12] For these model years, the fleet operator will need to use the applied off-road emission factor for the purposes of compliance with the proposed regulation.

[13] Actual engine emission standard will vary. Phased in sales averaging 1.2 to 0.2 g/bhp-hr between 2007 and 2010 model years

California Off-Road Emissions Regulation For Compression-Ignition Engines And Equipment; October 22, 2004

Diesel, 2005. Diesel Technology Forum: Farming, Mining & Construction; http://www.dieselforum.org/where-is-diesel/farming-mining-construction; 2005

DieselNet, 2003. DieselNet: Technology Guide: Diesel Emission Control; http://www.dieselnet.com/tech/engine_control.html; August, 2003

U.S. EPA, 2000. Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, EPA420-R-00-026, U.S. EPA, December 2000.

VI. ESTIMATED EMISSIONS FROM IN-USE OFF-ROAD DIESEL VEHICLES

This chapter discusses the emissions inventory for off-road diesel vehicles greater than 25 hp. It summarizes how the various data sources were used to update the inventory, and provides estimates of populations and emissions from off-road diesel vehicles between 2000 and 2030.

A. Overview

To develop the emissions estimate from in-use off-road diesel vehicles, staff utilized the ARB's OFFROAD2007 model, which was updated to incorporate data and information from the following sources summarized in Table VI-1 below:

- MacKay & Company Construction Universe Study (MacKay, 2003) of nationwide construction equipment population and activity;
- TIAX Public Fleet Survey (TIAX, 2003) on off-road diesel equipment owned by public fleets in California;
- Yengst & Associates Equipment Analysis Reports (Yengst, 2003-2005) for various types of construction equipment nationwide;
- United States Environmental Protection Agency (U.S. EPA) NONROAD model (USEPA, 2004)/ Power Systems Research (PSR, 2000) for population of industrial equipment;
- Air Transport Association (ATA, 2004) data for ground support equipment (GSE) population;
- ARB's Off-Road Diesel Equipment Survey (ARB, 2006a) of off-road diesel vehicles owned by both public and private entities;
- ARB's Off-Road Mini Survey (ARB, 2006b) on average age of construction equipment by equipment type; and
- Input from stakeholders and industry representatives during the workshop and workgroup process for the in-use off-road diesel vehicle regulation (2004-2006).

The OFFROAD2007 model provided the baseline emission estimates of diesel PM and NOx for calendar year 2000, in addition to emission forecasts to future years: 2010, 2015, 2020, 2025 and 2030. The OFFROAD2007 model reflects updated population, annual activity, useful life, growth and emissions deterioration from the sources previously mentioned. Details of the inventory methodology are found in Appendix E.

Staff believe that the emissions inventory is based on the best available information to date and provides a reasonable estimate of the emissions from mobile in-use off-road diesel vehicles greater than 25 hp.[14]

[14] The emissions and populations estimates presented are for vehicles greater than 25 horsepower, since proposed in-use off-road diesel vehicle regulation would cover vehicles 25 horsepower and greater. Vehicles at exactly 25 horsepower are not included in the inventory estimates here, but staff estimates that such vehicles represent a negligibly small portion of the inventory.

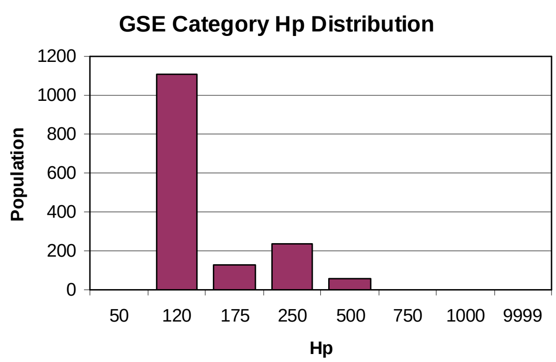
Table VI-1 - Emissions Inventory Data Sources

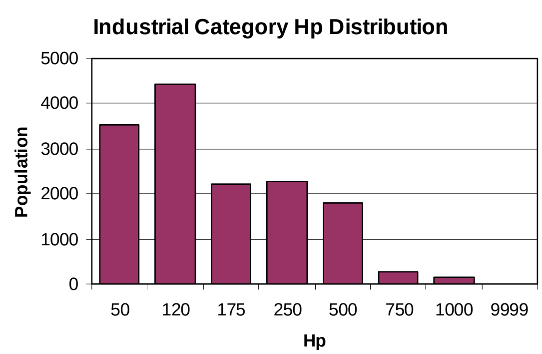
Category	Data	Source
Airport Ground Support (GSE)	Population	ATA (2004)
	Activity	ARB Survey (2006a), ATA (2004)
	Useful Life	ARB Survey (2006a), ATA (2004)
	Growth	ATA (1997)
Construction and Mining	Population	MacKay (2003), ARB Survey (2006a), PSR (2000)
	Activity	MacKay (2003), ARB Survey (2006a), TIAX (2003)
	Useful Life	MacKay (2003), ARB Surveys (2006a, 2006b), TIAX (2003)
	Growth	EEA (1995), REMI (2001)
Industrial	Population	PSR (2000)
	Activity	ARB Survey (2006a)
	Useful Life	PSR (1996)
	Growth	EEA (1995)
Oil Drilling	Population	ARB Survey (2006a)
	Activity	ARB Survey (2006a)
	Useful Life	ARB Survey (2006a)
	Growth	ARB Survey (2006a)

B. Population Distribution for In-use Off-road Diesel Vehicles by Category

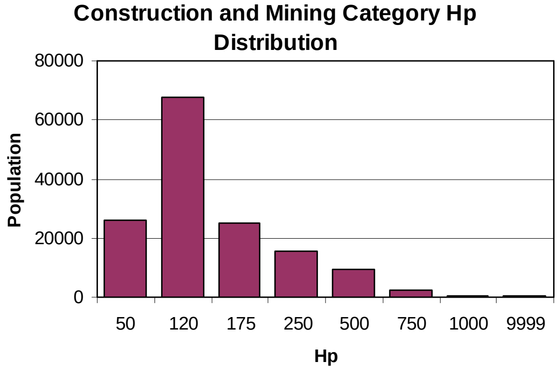
Figure VI-1 shows the 2000 population distribution of equipment by horsepower groups. The 51-120 hp group contains the majority of the population for each category: Ground Support Equipment (72 percent), Construction and Mining (46 percent), Industrial (30 percent), and Oil Drilling (36 percent).

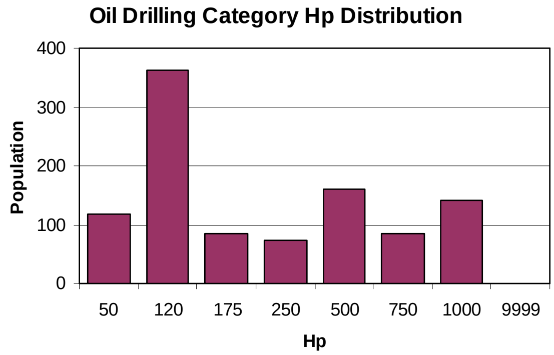
Figure VI-1 - Population Distribution by Horsepower Group (2000)[15]





[15] The horsepower categories in the bar charts are labeled with the maximum horsepower. For example, the 50 hp column indicates vehicles with 26-50 hp, the 120 hp column indicates 51-120 hp, and so on.





Staff estimates that in 2005, there were 179,663 in-use off-road diesel vehicles with engines greater than 25 hp. Table VI-2 through Table VI-5 show the most populous vehicle types in each fleet category.

Table VI-2 - Top 10 Vehicle Types in the Construction and Mining Category

Vehicle Category	2005 Population
Tractors/Loaders/Backhoes	30,665
Skid Steer Loaders	29,138
Rubber Tired Loaders	19,580
Excavators	19,354
Crawler Tractors	16,130
Trenchers	8,364
Rollers	7,814
Graders	6,777
Rough Terrain Forklifts	6,771
Off-Highway Tractors	3,215
Total Vehicles	147,808

Table VI-3 - Top 5 Vehicle Types in the GSE Category

Vehicle Category	2005 Population
Baggage Tug	538
Cargo Loader	317
A/C Tug Narrow Body	267
Belt Loader	260
Other GSE	105
Total Vehicles	1,487

Table VI-4 - Top 3 Vehicle Types in the Industrial Category

Vehicle Category	2005 Population
Aerial Lifts	5,341
Forklifts	5,142
Other General Industrial Equipment	4,793
Total Vehicles	15,276

Table VI-5 - Top 2 Vehicle Type in the Oil Drilling Category

Vehicle Category	2005 Population
Drill Rig (Mobile)	20
Workover Rig (Mobile)	1,001
Total Vehicles	1,021

The statewide population is grown from the base year 2000 by applying a growth factor that was derived from category-specific economic indicator data, such as employment, dollars spent, sales and fuel expenditures. The population of in-use off-road diesel vehicles subject to the proposed regulation increases approximately 37% from 2000 to 2020, as shown below in Table VI-6.

Table VI-6 - In-Use Off-road Diesel Vehicle Statewide Population (2000-2020)

Year	Population
2000	164,250
2001	167,332
2002	170,410
2003	173,499
2004	176,590
2005	179,663
2006	182,675
2007	185,688
2008	188,701
2009	191,714
2010	194,727
2011	197,772
2012	200,731
2013	203,689
2014	206,648
2015	209,607
2016	212,537
2017	215,467
2018	218,398
2019	221,330
2020	224,247

C. Tier Distribution of Off-Road Diesel Vehicles

The following tables show the age at which 50 percent of the population is retired, defined as the median useful life. The longest any vehicle is modeled to be in-use is up to twice the age when 50 percent retired (twice the median life). Thus, since the longest median useful life is 38 years, the oldest age any vehicle is modeled is 76 years old.

Table VI-7 - Useful Life of Top 10 Vehicle Types in the Construction and Mining Category

Vehicle Category	Age @ 50% Retired (years)
Tractors/Loaders/Backhoes	18
Skid Steer Loaders	13
Rubber Tired Loaders	21
Excavators	17
Crawler Tractors	29
Trenchers	28
Rollers	20
Graders	23
Rough Terrain Forklifts	16
Off-Highway Tractors	31

Table VI-8 - Useful Life of Top 5 Vehicle Types in the GSE Category

Vehicle Category	Age @ 50% Retired (years)
Baggage Tug	25
Cargo Loader	18
A/C Tug Narrow Body	30
Belt Loader	22
Other GSE	22

Table VI-9 - Useful Life of Top 3 Vehicle Types in the Industrial Category

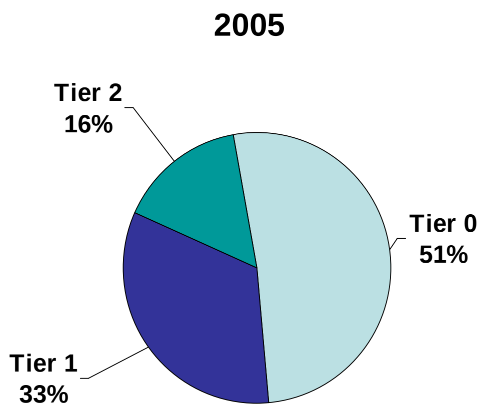
Vehicle Category	Age @ 50% Retired (years)
Aerial Lifts	16
Forklifts	12
Other General Industrial Equipment	16

Table VI-10 - Useful Life of Top 2 Vehicle Type in the Oil Drilling Category

Vehicle Category	Age @ 50% Retired (years)
Drill Rig (Mobile)	38
Workover Rig (Mobile)	38

In 2005, the total statewide fleet is comprised of vehicles having Tier 0 (or Uncontrolled), Tier 1, and Tier 2 engines, with the majority (52 percent) of the equipment population having Tier 0 engines. Figure VI-2 shows the tier distribution for the Construction and Mining category in 2005 and 2020. By 2020, the same fleet is comprised of a mix of Tier 0, Tier 1, Tier 2, Tier 3 and Tier 4 equipment, with the majority (56 percent) being Tier 4. However, because of their long useful life, 8 percent of the equipment population will still be Tier 0 in 2020. This change in fleet composition is the result of normal attrition, and does not include projections of expedited fleet turnover as a result of the proposed regulation.

Figure VI-2 - Emission Standard Tier Distribution of Vehicle Population Subject to Proposed Regulation (Years 2005 and 2020)



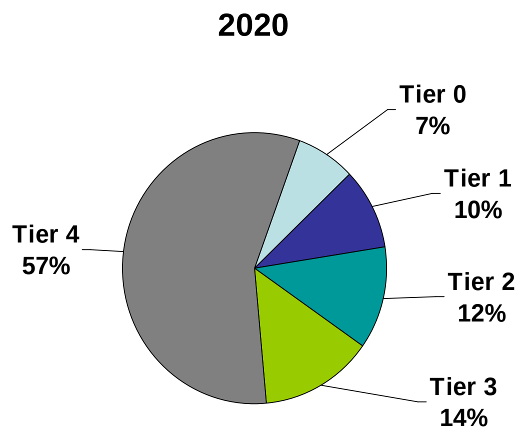
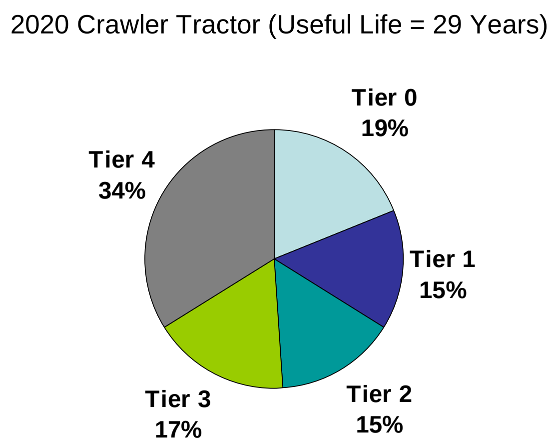
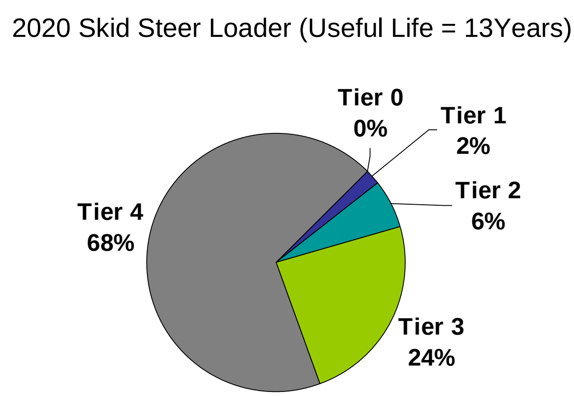


Figure VI-3 further better illustrates the impact of the long useful life of the two types of in-use off-road diesel vehicles that would be subject to the regulation, and how various types of equipment can have different tier distributions in any given year. For example Figure VI-3 shows the 2020 statewide tier distribution of crawler tractors, which have long useful lives (29 years), compared to skid steer loaders, which have shorter useful lives (13 years). Skid steer loaders have a higher turnover rate, thus resulting in 68 percent of the population being Tier 4 in 2020, as compared to crawler tractors which turn over at a much slower rate, and have a Tier 4 population in 2020 of only 34 percent.

Figure VI-3 - Tier Distribution and Useful Life





D. Current Emission Estimates for In-use Off-road Diesel Vehicles

Staff estimates that in-use off-road diesel vehicles greater than 25 hp in the Airport Ground Support (GSE)[16], Construction & Mining, Industrial[17] and Oil Drilling categories resulted in approximately 23 tons per day or 8,259 tons per year of diesel PM emissions statewide in 2005. These vehicles were also responsible for approximately 386 tons per day or 140,964 tons per year of NOx emissions statewide in 2005. Estimates of statewide 2000 and 2005 diesel PM and NOx from in-use off-road diesel vehicles greater than 25 hp are presented in Table VI-11.

Table VI-11 - Estimated Statewide Off-Road Diesel Emissions in 2000 and 2005 (tons per day)

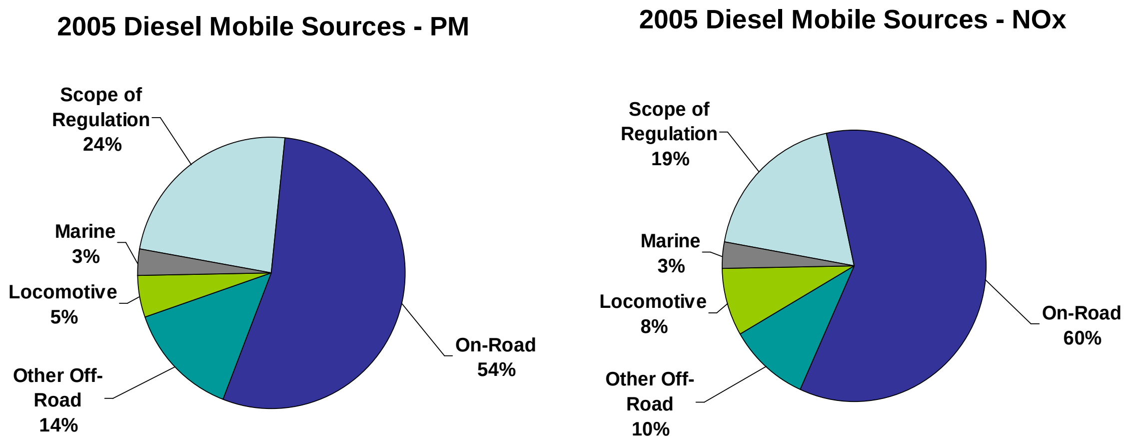
Category	2000 Emissions (tpd)			2005 Emissions (tpd)		
	Population	NOx	PM	Population	NOx	PM
Airport Ground Support (GSE)	1,534	2.9	0.2	1,724	2.9	0.2
Construction and Mining	147,005	358.1	21.4	161,403	332.0	19.8
Industrial	14,690	36.0	1.9	15,516	32.0	1.6
Oil Drilling	1,021	21.9	1.1	1,021	19.3	1.0
Total	164,250	419.0	24.7	179,663	386.2	22.6

Off-road diesel vehicles are a significant contributor to the State's total diesel mobile source emission inventory of PM and NOx. Figure VI-4 illustrates that off-road diesel vehicles are responsible for 24 percent of total statewide mobile source PM emissions, and 19 percent of total statewide diesel mobile source NOx emissions. Off-road diesel vehicles are responsible for an estimated 23 percent of total statewide PM emissions, including emissions from stationary sources.

[16] The GSE category contains 6 equipment types (Catering Truck, Fuel Truck, Hydrant Truck, Lav Truck, Service Truck and Sweeper) that would not be subject to the proposed regulation because they contain on-road diesel engines; these equipment types are included in the OFFROAD2007 model, but were removed from the inventory in support of this regulation.

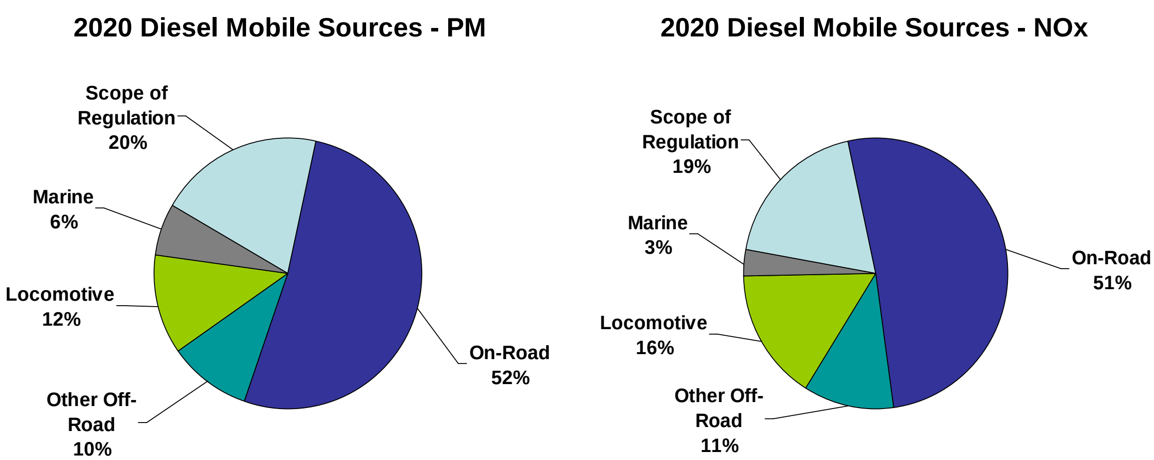
[17] Sweeper/Scrubbers were removed from the Industrial category because most have on-road engines and would not be subject to the proposed regulation.

Figure VI-4 - Contribution to Statewide Diesel Mobile Source PM and NOx Inventory (2005)



Without the regulation, by 2020, even though newer off-road diesel vehicles will replace older vehicles, the contribution from off-road diesel engines would continue to be a major contributor to PM and NOx emissions. The projected emission estimates for off-road diesel equipment that would be subject to the regulation are shown in Figure VI-5.

Figure VI-5 - Contribution to Statewide Diesel Mobile Source PM and NOx Inventory (2020)



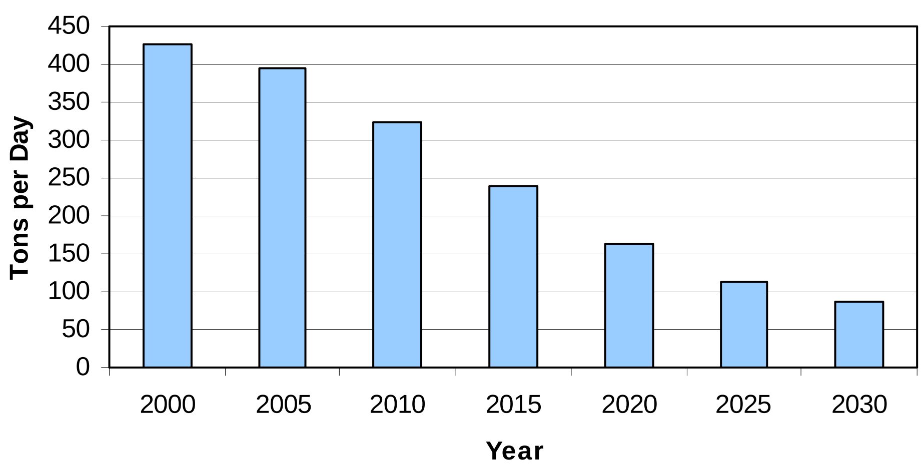
Even though emissions decline with normal turnover to newer, cleaner vehicles, it is not enough to meet state and federal AAQS for PM and ozone, nor to meet the risk reduction goals of the Diesel Risk Reduction Plan. Table VI-12 shows the projected statewide emission inventory of PM and NOx from the in-use off-road diesel vehicles between 2010 and 2030 by industry sector. Construction and mining is the largest contributor from of all sectors subject to the rule.

Table VI-12 - Estimated Statewide Off-Road Diesel Emissions 2010 - 2030 (tons per day)[18]

Category	2010 (tpd)		2015 (tpd)		2020 (tpd)		2025 (tpd)		2030 (tpd)	
	NOx	PM	NOx	PM	NOx	PM	NOx	PM	NOx	PM
Airport Ground Support	2.7	0.2	2.3	0.2	1.8	0.1	1.4	0.1	1.0	0.0
Construction and Mining	274.0	15.8	203.8	10.8	138.1	6.4	96.4	3.7	73.6	2.2
Industrial	25.8	1.2	17.3	0.8	10.2	0.4	6.1	0.2	4.1	0.1
Oil Drilling	16.2	0.8	12.8	0.6	9.9	0.4	7.6	0.3	6.0	0.2
Total	318.6	18.0	236.1	12.3	159.9	7.3	111.5	4.2	84.7	2.6

Figure VI-6 and Figure VI-7 show the anticipated changes in NOx and PM emissions, respectively, from 2000 to 2030 for all vehicle categories that would be subject to the regulation. These estimates include the benefits from the introduction of new vehicles having engines that meet the new diesel engine standards, but do not include the projected reductions that would be expected from the implementation of the proposed regulation.

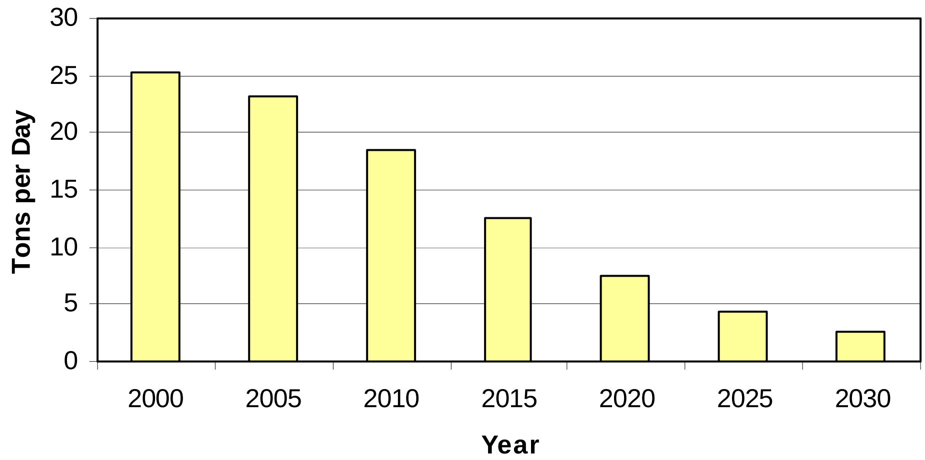
Figure VI-6 - Statewide Off-Road Diesel NOx Emissions in 2000-2030



Annual growth rates for off-road diesel equipment were derived based on economic indicator data, such as employment, sales and total dollars spent. Appendix E contains additional details on the growth rate methodology for each category.

[18] Populations and emissions are for mobile off-road diesel vehicles that are 25 horsepower and greater only. Estimates do not include portable equipment or any vehicles propelled by on-road engines such as airport ground support equipment (GSE) service trucks except workover rigs.

Figure VI-7 - Statewide Off-Road Diesel PM Emissions in 2000-2030



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VII. PROPOSED REGULATION

This chapter discusses the key requirements of the proposed regulation. This chapter begins with a general overview of the proposed regulation and then explains each of the proposed regulation's major requirements. This chapter is intended to satisfy the requirements of Government Code section 11343.2, which requires that a non-controlling "plain English" summary of the regulation be made available to the public.

This chapter also explains which portions of the regulation apply to small fleets, which portions apply to medium and large fleets, how the regulation applies to rental fleets, and how the regulation applies to dealers of vehicles.

A. Proposed Regulation Overview

The proposed regulation applies to anyone who owns or operates diesel-powered off-road vehicles in California with engines at or greater than 25 hp.

The regulation would be contained in a new section 2449 in a new Article 4.8 entitled "Emission Standards for In-Use Diesel Off-road Fleet." of Title 13, Chapter 9, California Code of Regulations (CCR). The regulation itself is included in Appendix A; an outline of the subsections of the regulation is presented in Appendix A1. The following discussion provides a summary of the regulation's requirements, schedule, and special provisions. A more detailed discussion of the proposed regulation is provided later in this chapter.

1. Regulation Requirements

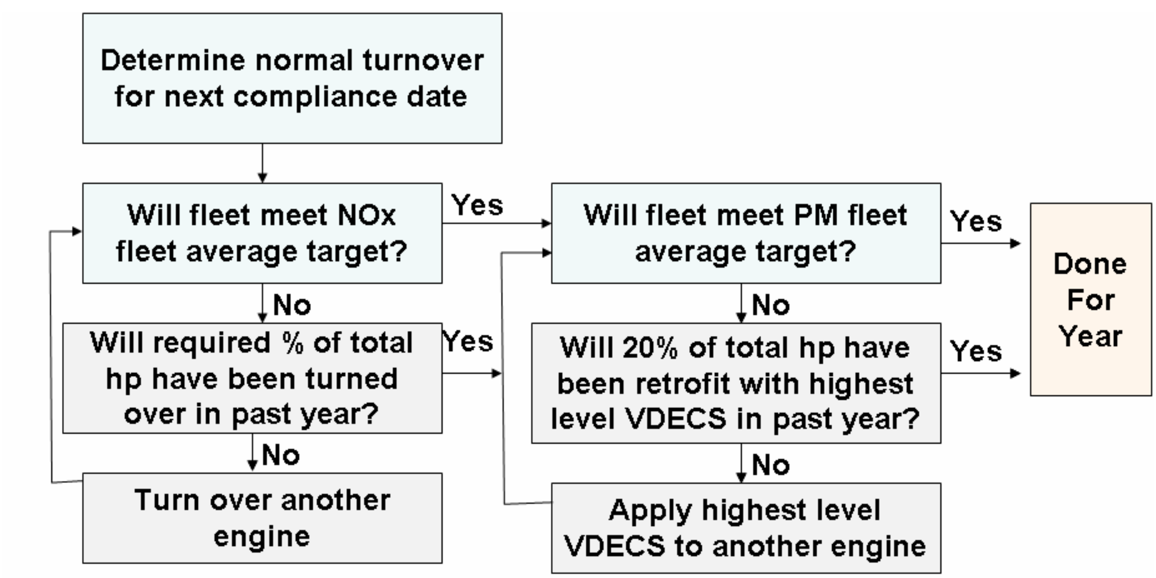
All fleets would be required to report their affected equipment to ARB starting in 2009. Then, annually, as vehicles are repowered, replaced, retired, or retrofit, the changes would need to be reported annually to ARB.

All fleets would have to meet the PM reduction requirements. Large and medium fleets would also have to meet NOx reduction requirements. Each year, the PM and NOx requirements could be satisfied by demonstrating the best available control technology (BACT) requirements were met or by demonstrating the fleet average targets were met. To meet the PM reduction requirements, each year, fleets could comply by installing the highest level verified diesel emission control devices on 20 percent of the horsepower in their fleet or by taking a variety of actions to meet the PM average target by the next compliance date. To meet the NOx reduction requirements, each year, fleets could comply by turning over a certain percent of the fleet horsepower (8 percent each year between 2010 and 2015 and 10 percent each year thereafter) or by taking a variety of actions to meet the NOx average target by the next compliance date. The targets decline over time, requiring fleets to reduce their emissions as time goes on. To meet the fleet averages, fleets would have the option of retrofitting their vehicles with verified diesel emission control devices that reduce NOx and/or PM, repowering them with cleaner engines (i.e., replace the engine in an existing vehicle), retiring them from the fleet, or replacing them with cleaner vehicles (new or used).

Some fleets would meet the NOx averages with normal turnover or by slightly accelerating the turnover of vehicles. However, if a fleet were unable to meet the NOx target (for example, because it has a lot of older, dirtier vehicles), it could instead turn over the BACT required percent of its fleet horsepower per year. To meet the turnover requirements, fleets may replace their dirtiest vehicles with cleaner vehicles (either new or used), repower their dirtiest vehicles with cleaner engines, designate some of their vehicles as low-use vehicles, retire vehicles, or use long term rental vehicles in place of the dirtiest vehicles. Many of these actions would also improve the PM average for the fleet. Any fleet that installs the highest level PM exhaust retrofits on 20 percent of its fleet horsepower would be in compliance with the PM requirements for that year, even if it does not meet its PM target. If the fleet is able to meet the PM average target by installing fewer retrofits, then it would not need to retrofit the full 20 percent of its horsepower. Similarly, if a fleet is able to meet the NOx target by turning over fewer than the required 8 or 10 percent of its horsepower, then it would not need to turn over the full 8 or 10 percent.

The regulation would never require a fleet to turn over more than 8 percent of its horsepower in a year from 2010 to 2015 (10 percent after), nor to apply exhaust retrofits to more than 20 percent of its horsepower in a year. Figure VII-1 provides a flow chart showing the annual compliance process for large and medium fleets. Small fleets are not subject to the NOx requirement or engine turnover and would only be subject to the PM requirements starting in 2015; only the right side of the flow chart applies.

Figure VII-1 - Annual Compliance Process for Large and Medium Fleets



Note: Turn over means repower with cleaner engine, replace vehicle with used vehicle or new vehicle, designate as low-use, or decrease fleet size. If NOx retrofits become available, they may be used in lieu of turnover.

Finally, the regulation would require that operators of off-road diesel vehicles shut down their vehicles rather than idle for more than 5 minutes, unless such idling is necessary for proper operation of the vehicle.

2. Regulation Schedule

The limit on unnecessary idling would become effective as soon as the regulation is certified by the Secretary of State, which is expected to occur in spring of 2008. The requirements to report information about affected vehicles would begin in 2009.

Large fleets (more than 5,000 hp) would have to begin meeting the fleet average targets on March 1, 2010. Medium fleets would need to begin meeting the fleet average on March 1, 2013, and small fleets (less than or equal to 1,500 hp, as defined below) would have until March 1, 2015. The fleet average targets would decline over time until 2020 (or until 2025 for small fleets). Small fleet requirements are generally delayed by 5 years behind those for medium fleets.

3. Special Provisions

The regulation has special, less-stringent provisions for low-use vehicles (those that operate less than 100 hours per year in California), specialty vehicles, snow removal equipment, and vehicles used in emergency operations.

The regulation also requires dealers and sellers to disclose to buyers that the vehicles being sold may be subject to the requirements of the regulation.

B. Purpose

As specified in subsection (a) of the proposed regulation, the purpose of the proposed regulation is to reduce diesel particulate matter (PM) and criteria pollutant emissions, including NOx, from in-use off-road diesel vehicles.

C. Applicability

Subsection (b) of the proposed regulation describes to whom the regulation would apply. The fleet average and turnover and retrofit requirements of this regulation would apply to any person, business, or government agency who owns vehicles with affected engines in California. Affected engines include diesel-fueled engines with maximum power of 25 horsepower (hp) or greater that are used to provide motive power in a workover rig or to provide motive power in any other motor vehicle that (1) is not designed to be registered and driven safely on-road, and (2) is not an implement of husbandry or off-highway vehicle (recreational).

The proposed regulation only addresses engines that provide motive power to mobile vehicles, i.e., engines that drive self-propelled vehicles. The proposed regulation does not apply to stationary equipment. The proposed regulation also does not apply to portable engines that power equipment that is not self-propelled, such as portable generators, compressors, and chippers. Such portable equipment is typically towed behind a truck. In addition, the proposed regulation also does not apply to auxiliary engines in mobile equipment like cranes and drill rigs as long as these engines do not provide motive power. Portable engines such as those mentioned above are already addressed by the Portable Equipment Air Toxic Control Measure (ATCM) in title 17, CCR, section 93116 et seq.

Figure VII-2 provides a flow chart that shows how to determine whether a vehicle is on-road or off-road (and therefore potentially subject to this proposed regulation). One key factor in determining whether a vehicle is potentially subject to the regulation is whether it has the design and safety features to allow it to be registered and driven safely on-road. Table VII-1 below summarizes the design and safety features necessary for a vehicle to be registered to drive on-road in California. With two exceptions, trucks and other vehicles that drive on-highway and that can be registered and driven safely on-road and that meet the criteria summarized in Table VII-1 are not subject to the proposed regulation regardless of how they are actually used. The two exceptions are (1) workover rigs, and (2) vehicles, such as a loader used to pick up yard waste off of residential streets, that were designed for off-road use and that have off-road engines but that have been modified to be driven safely on-road. Although workover rigs are often registered for on-road use, they are included in the proposed regulation because they spend the vast majority of their operating hours in off-road use working on oil or gas wells. ARB has an existing regulation for publicly owned on-road diesel fleets in title 13, CCR, sections 2022 and 2022.1; and is developing another control measure to address emissions from privately owned on-road diesel fleets (http://www.arb.ca.gov/msprog/onrdiesel/onrdiesel.htm).

Figure VII-2 - Flowchart to Determine If Off-road or On-road

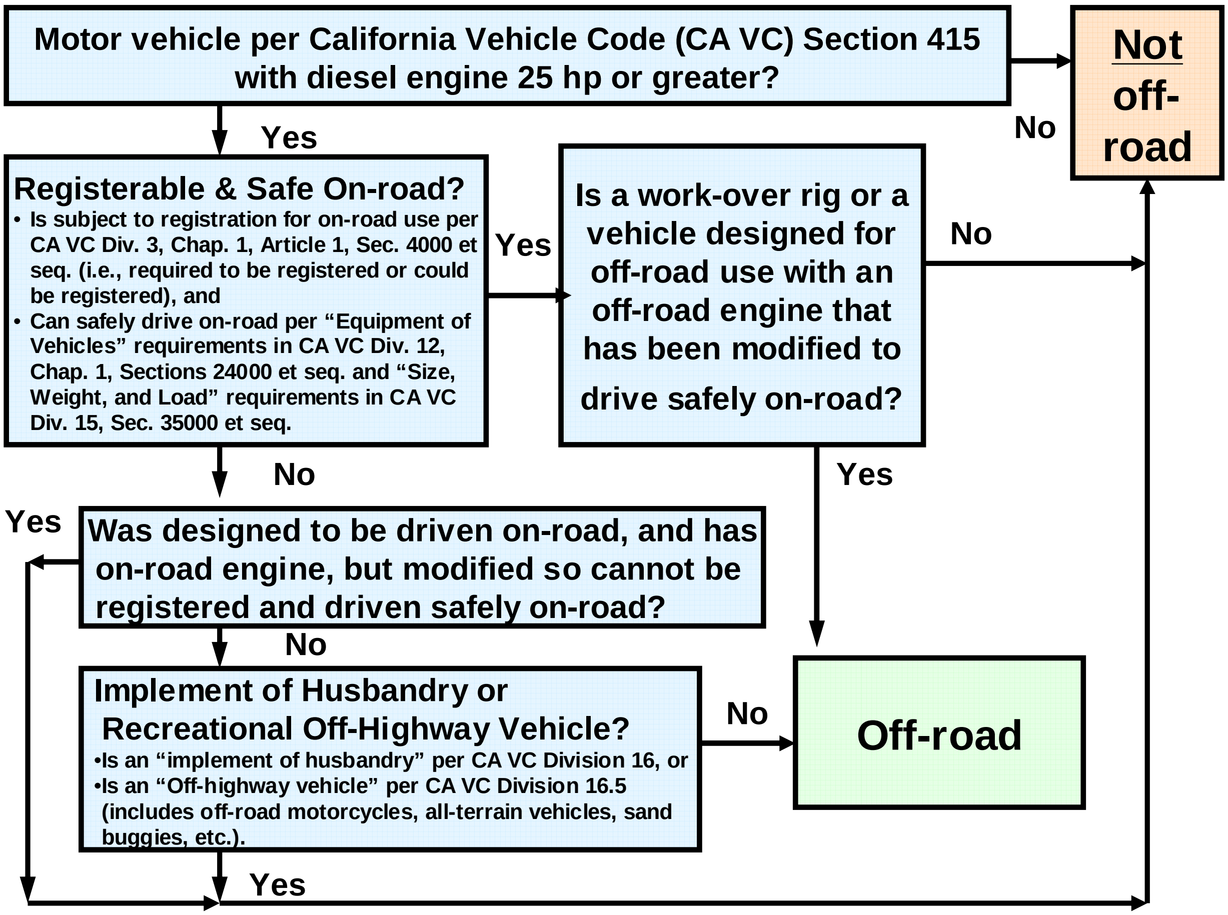


Table VII-1 - Summary of California Vehicle Code Requirements to be Registered and Safely Driven On-road[19]

Criteria	Citation	Summary
Height	24008.5	Maximum height of the frame of a passenger car is 23 inches. Maximum height of the frame of a car of gross vehicle weight rating (GVWR) up to 4,500 pounds is 37 inches, GVWR 4,501 to 7,500 is 30 inches, and GVWR 7,501 to 10,000 pounds is 31 inches.
	35250	Maximum height of a vehicle or load in vehicle is no more than 14 feet.
	35252	A pilot car may operate a vertical clearance measuring device that may be higher than 14 feet when escorting a permitted over-height load.

[19] Further requirements for being registered are in the Vehicle Code at Division 3, Chapter 1, Article 1: Vehicles subject to Registration; Division 12, Chapter 2, Article 5: Signal Lamps and Devices; Division 12, Chapter 2, Article 6: Side and Fender Lighting Equipment; and Division 12, Chapter 2, Article 8: Warning Lights and Device.

Criteria	Citation	Summary
Weight	35550	A vehicle's weight upon in any one axle shall not exceed 20,000 pounds. The vehicles weight shall not exceed 10,500 pounds per wheel.
	35540	On a bus, the gross weight on any on axel shall not exceed 20,500 pounds.
Length	35400	Single vehicle length may be no longer than 40 ft.
	35401	Any combination of vehicles when coupled together may not exceed 65 feet. If a combination of vehicles coupled together includes a truck tractor, semi-trailer, and a semi-trailer or trailer, it may not exceed a total length of 75 feet.
Lights	24400	Must have two headlights, one on either side of the front of the vehicle between 22 and 54 inches from the ground.
	24600	Two red tail lamps must be mounted on both sides of the rear of a vehicle between 15 and 72 inches from the ground.
	24603	Two red stop lamps must be mounted on both sides of the rear of a vehicle between 15 and 72 inches from the ground.
	24606	Two white or clear backup lights must be equipped at equal heights on both sides of the rear of the vehicle.
	24951	Vehicles must be equipped with a lamp-type turn signal system capable of clearly indicating any intention to turn to the right or to the left.
	24953	The turn signal lamps in the front of the vehicle must be white or amber, and the signal lamps in the rear must be red.
	25100	Every vehicle (except those provided in subdivisions (b) and (d) of 25100) that is 80 inches or wider shall be equipped in darkness with amber lighting on both sides of the vehicle.
Other Equip-ment Specif-ications	24615	If a vehicle is incapable of operating at a speed of more than 25 miles per hour, it must have a slow moving vehicle emblem hanging off of the rear of the vehicle.
	26301	If vehicle's gross weight exceeds 14,000 pounds it shall be equipped with power breaks. If the vehicle exceeds 18,000 pounds it shall be equipped with two-stage hydraulic actuators that will increase braking effect of brakes.
	26700	Vehicle must have a windshield unless it is specified in section 5400 that it is not required.
	26706	If vehicle is required to have a windshield, then it must have an operating windshield wiper.
	26709	Vehicle must have two mirrors that reflect 200 ft in the reverse direction. One of the two mirrors shall be affixed to the left-hand side of the car.
	27000	Vehicle must have a horn that emits a sound which is audible from a distance not less than 200 feet under normal circumstances.
	27510	All vehicles must have an adequate muffler and exhaust system

Criteria	Citation	Summary
	27600	If a vehicle has three or more wheels it must have fenders, covers or devices (including flaps or splash aprons) that effectively decrease the spray of mud or water to the rear of the vehicle. The equipment that decreases the spray must be at least as wide as the tire tread.

Some off-road vehicles that drive incidentally on-road to travel from job site to job site are required by the California Vehicle Code to be tagged with California Special Construction Equipment plates (California Vehicle Code Sections 565 and 570). However, having a special construction equipment plate does not mean a vehicle can be registered and driven safely on-road. Such vehicles with special construction equipment plates would most typically be considered off-road and thus subject to the requirements of this proposed regulation.

For the most part, the regulation would apply to the owners of affected vehicles, regardless of who is operating them. The idling requirements would apply to operators of affected vehicles. The only exceptions are for vehicles in incidental ownership (such as temporary ownership of non-operated vehicles by financing companies and new or used equipment dealers) and for leased vehicles if specified in the lease agreement (see following sections).

The proposed regulation would affect a number of industries – including construction, mining, rental, government, landscaping, recycling, landfilling, manufacturing, warehousing, ski industry, composting, airport ground support equipment, industrial, telephone and cable providers, and other operations.

The proposed regulation would not cover locomotives, commercial marine vessels, marine engines, recreational vehicles (such as off-road motorcycles, all-terrain vehicles, and golf carts), or combat and tactical support equipment.

The proposed regulation also would not apply to equipment or vehicles used solely in agricultural operations. Equipment that is used by its owner for over half its annual operating hours for agricultural operations and part of the time for other types of work (such as a backhoe used at times for logging and at times for construction work) is considered agricultural, and would be exempt from the requirements of the proposed regulation except the reporting and labeling requirements. A vehicle that is rented or leased by its owner for use in agricultural and nonagricultural operations by others is subject to the regulation unless it is used <u>exclusively</u> for agricultural operations.

Equipment already subject to the Regulation for Mobile Cargo Handling Equipment at Ports and Intermodal Rail Yards (CHE Regulation, title 13, CCR, section 2479) would not be subject to the proposed regulation. The CHE Regulation applies to off-road, mobile equipment operated at a port or intermodal rail yard to transport cargo or used to perform maintenance and repair activities that are routinely scheduled or that are due to predictable process upsets.[20] These equipment types include, but are not limited to, mobile cranes, rubber-tired gantry cranes, yard trucks, top handlers, side handlers, reach stackers, forklifts, loaders, excavators, dozers, sweepers, and aerial lifts. Off-road equipment brought into a port or intermodal rail yard terminal for construction projects or unexpected repairs is not subject to compliance with the CHE Regulation, and therefore, would be required to meet all requirements of this proposed regulation. Additionally, off-road equipment used at a port or intermodal rail yard solely to transport personnel or deliver fuel are not required to meet the performance standards of the CHE Regulation, and therefore, would be required to meet all requirements of this proposed regulation.

1. Parts of Regulation Applicable to Small Fleets

Requirements in the proposed regulation for small fleets (as defined below) differ from those for large and medium fleets. The following subsections of the regulation apply only to large and medium fleets and therefore may be disregarded by small fleets:

- (d)(1)(A) – The NOx fleet average requirements do not apply to small fleets.
- (d)(2)(A) – The mandatory turnover requirements do not apply to small fleets.
- (d)(3)(B) – The requirements for having a written idling policy do not apply to small fleets.
- (d)(7)(B)2.a. – The requirements for adding vehicles differ for small versus medium and large fleets. Those in (d)(7)(B)2.a. do not apply to small fleets.
- (d)(10)(A) – The requirements for compliance after the final compliance date differ for small versus medium and large fleets. Those in (d)(10)(A) do not apply to small fleets.

2. Parts of Regulation Applicable to Large and Medium Fleets

The following subsections of the regulation apply only to small fleets and therefore may be disregarded by large and medium fleets:

- (d)(1)(B) – The fleet average requirements for small fleets are in (d)(1)(B) and do not apply to large or medium fleets.
- (d)(7)(B)2.b. – The requirements for adding vehicles differ for small versus medium and large fleets. Those in (d)(7)(B)2.b. do not apply to large or medium fleets.

3. How Regulation Applies to Sellers and Dealers of Vehicles

This section discusses how the proposed regulation applies to sellers of affected vehicles, such as equipment dealers and auction houses or financing companies who do not operate the vehicles. The only part of the regulation that would apply to such sellers of vehicles is the disclosure of regulation applicability requirement in section (j). That is, sellers must notify buyers that the regulation may apply.

[20] For definitions of "port" and "intermodal rail yard," please refer to the CHE Regulation, section 2479, title 13, California Code of Regulations. A discussion of California's ports and intermodal rail yards is also available in the Initial Statement of Reasons (ISOR) for the CHE Regulation: http://www.arb.ca.gov/regact/cargo2005/cargo2005.htm.

Vehicles that are temporarily owned by dealerships or are incidentally owned by financing companies and are awaiting sale would not be subject to the labeling, recordkeeping, reporting, or performance requirements of the regulation provided the vehicles are not being operated (other than operation for sales demonstration or maintenance). Thus, dealers and financing companies that do not operate vehicles and that do not offer them for rent would not need to report their vehicles and need not comply with any fleet averaging or mandatory turnover or retrofit provisions. Dealers that hold vehicles for sale and also rent them out or lease them would be responsible for compliance as described below for rental and lease companies.

The regulation would also place restrictions on fleets regarding adding vehicles of certain cleanliness to their fleets. For example, fleets may not add vehicles with Tier 0 engines to their fleets after March 1, 2009. However, compliance with these restrictions would be the responsibility of the buyer, not the seller. Sellers hold no responsibility for verifying that buyers are complying with the adding vehicles requirements. However, disclosure of the applicability requirements for the proposed regulation would apply to any person who sells a vehicle in California with an affected engine.

4. How Regulation Applies to Rental and Lease Companies

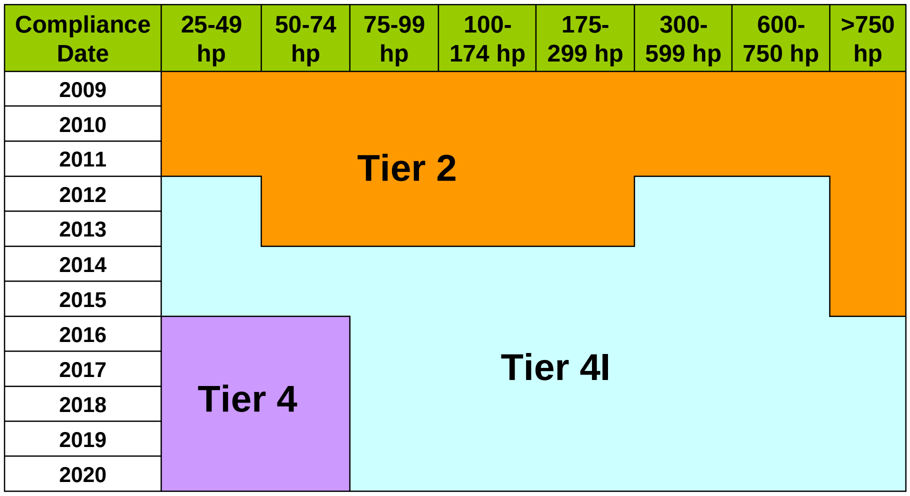
The regulation would treat rental and lease companies just like any other fleets. Thus, the default situation in the regulation is that rental vehicles are the responsibility of the rental company rather than the user.

For vehicles leased for a period of a year or more, if a rental or lease company and the lessee agree in the lease agreement that the vehicle will be the responsibility of the lessee, it may be excluded from the rental company's fleet that year and included in the fleet of the lessee. If rental and leasing companies are selling vehicles which were formerly part of their rental fleet and the rental vehicle was operated less than 100 hours in the past year, such vehicles may be treated like other vehicles being held for sale, as described in the section above.

Vehicles under a long-term lease of period of a year or more that was in place before the regulation takes effect would be the responsibility of the lessee rather than the leasing company.

Many rental companies have relatively new fleets. Fleets who own vehicles less than 10 years old would not need to turn them over to reduce NOx but may need to install exhaust retrofits to meet the PM targets. One simple way for such fleets to comply with the proposed rule would be to ensure that all vehicles in the fleet are clean enough to meet the fleet average targets for both PM and NOx. Fleets choosing such an option would avoid the need for exhaust retrofits and the need for tracking of fleet average targets and indices. Figure VII-3 below shows the emission standard tier that vehicles of various horsepowers would need to meet to satisfy both the NOx and PM fleet average targets for each large and medium fleet compliance year. Of course, fleets with newer vehicles could also meet both the PM and NOx targets with a mix of vehicle ages (varying engine tiers) but would need to use the fleet calculator to determine that mix.

Figure VII-3 - Engine Tier to Move Fleet Closer to Fleet Average Targets – Large and Medium Fleets



- Tier 2 available starting 2001-2006, depending on hp
- Tier 4I available starting 2008-2012, depending on hp
- Tier 4 available starting 2013 for 25-74 hp

D. Definitions

The proposed regulation provides definitions of all terms that are not self-explanatory. There are over 40 definitions to help clarify the regulation's requirements. The definitions listed in subsection (c) of the proposed regulation were developed by staff, with input from the public during workshops and workgroup meetings. Staff working on this regulation also coordinated with staff working on other diesel PM regulations to provide consistency with other regulations where it was practical. Please refer to Appendix A, subsection (c) for a list of definitions.

The sections below provide further detail regarding the definitions for combat and tactical support equipment, low-use vehicles, small business, and fleet size.

1. Combat and Tactical Support Equipment

Combat and tactical support equipment means equipment that meets military specifications, is owned by the U.S. Department of Defense and/or the U.S. military services or its allies, and is used in combat, combat support, combat service support, tactical or relief operations or training for such operations. Such equipment would be exempt from the proposed diesel regulation for national security reasons. Appendix F provides a letter from the Department of the Navy listing the equipment types included as combat and tactical support equipment.

2. Low-Use Definition

Low-use vehicle means a vehicle that operated in California less than 100 hours during the last reporting period, i.e., the preceding 12-month period running from March 1 to the end of February. Fleets may claim vehicles as low-use if they document with engine operating hour data that the vehicle actually operated less than 100 hours in the last year. Thus, vehicles claimed as low-use must be equipped with a properly functioning non-resettable hour meter. Fleets that have three years of operating records may also identify a vehicle as low use if the average annual hours of operation over the last three years is less than 100 hours per year.

Certain hours may be excluded when determining low-use status:

- Hours used for emergency operations are not counted; and
- Hours when vehicles operate outside California.

A discussion of why ARB staff is proposing that the low-use threshold be set at 100 hours per year is included in the Topics chapter.

3. Small Business

The proposed regulation uses the small business definition from the California Government code Section 11342.610. A small business must be independently owned and operated and not dominant in its field of operation. Under the current definition, businesses with the following characteristics can not be defined as small businesses:

- Utility, water company, or power transmission companies generating and transmitting more than 4.5 million kilowatt hours annually.
- Manufacturing enterprises with more than 250 employees.
- General construction companies with annual gross receipts over $9,500,000.
- Special trade construction, with annual gross receipts over $5,000,000.
- Transportation and warehousing with annual gross receipts over $1,500,000.

4. Fleet Size Definitions

A fleet would include all off-road vehicles and engines owned by a person, business, or government agency that are operated within California and subject to the regulation. The proposed regulation contains varying requirements depending on fleet size, with the strictest requirements impacting the largest fleets and the least strict requirements for the smallest fleets. In the proposed regulation, fleet size is determined by summing a fleet’s total horsepower (which the regulation calls “total maximum power”) from all affected vehicles. Low-use vehicles, dedicated snow-removal vehicles, and vehicles used solely for emergency operations may be excluded when determining fleet size. Table VII-2 summarizes the fleet size definitions.

Table VII-2 - Fleet Size Definitions

Fleet Size	Owner	Total Horsepower[21]
Small	Municipality	Less than or equal to 1,500 hp
	Small business (as defined in California Government Code 11342.610)	Less than or equal to 1,500 hp
	Municipality fleet in a low-population county	Any
Medium	Municipality	1,501 to 5,000 hp
	Business	Less than or equal to 5,000 hp and does not meet small fleet definition
Large	Municipality	Greater than 5,000 hp
	Business	Greater than 5,000 hp
	State and federal government fleets	Any

Large fleets are those with total horsepower greater than 5,000 hp. Parts of large fleets such as various divisions in a company or subsidiaries of a company may figure their fleet averages separately and report separately, but a fleet must meet large fleet requirements if the total vehicles under common ownership would be defined as a large fleet. All fleets owned by agencies either of the United States or the State of California (i.e., an agency in the judicial, legislative, or executive branch of the federal or state government) must meet the large fleet requirements.

Medium fleets are those with total horsepower less than or equal to 5,000 hp that are not small fleets. Typically, medium fleets will have total horsepower between 1,501 hp and 5,000 hp, but some fleets with total horsepower less than or equal to 1,500 hp will be considered medium fleets because they are not small businesses. Municipalities with 1,501 to 5,000 hp are also considered medium fleets.

Small fleets include (1) fleets owned by a small business with total horsepower of less than or equal to 1,500 hp and (2) all municipalities in low population counties irrespective of total horsepower. Low-population counties are shown in Figure VII-4 and in general are those with population of less than 125,000.

[21] The sum of horsepower of all affected vehicles is used to determine the fleet size. Low-use vehicles (those that operate less than 100 hours per year) need not be included in the sum.

All State and federal government fleets are considered large, regardless of total horsepower.

Figure VII-4 - Low-Population Counties

A discussion of why ARB staff defined fleet size as proposed is included in the Topics chapter.

E. Performance Requirements

Under the proposed regulation, each fleet must comply with the NOx requirements and/or PM requirements. Small fleets are subject to the PM requirements starting in 2015, but they are never subject to the NOx requirements. As described in subsection (d) in the proposed regulation, large and medium fleets would be subject to both PM and NOx requirements unless they are fleets operating exclusively in current federal attainment area counties that do not contribute to downwind exceedances of the state ozone standard (as determined in past transport assessments in ARB, 1990; ARB, 1993; ARB, 1996; ARB, 2001). These captive fleets would be subject only to the PM requirements and do not need to meet the NOx requirements. The attainment area counties are shown in Figure VII-5. Medium fleets' compliance dates begin in 2013 and large fleets' compliance dates begin in 2010. Each year, fleets would have to comply by meeting either the best available control technology (BACT) requirements or by demonstrating the fleet average targets have been met. The BACT requirements consist of a certain percent of annual fleet turnover and installation of PM exhaust retrofits. Fleets that choose to meet the fleet average targets may use any combination of strategies to meet the targets. The fleet average and BACT requirements are further described below.

Figure VII-5 - Federal Attainment Area Counties that do Not Contribute to Downwind Ozone Violations – (Captive fleets in these counties are not subject to NOx fleet average requirements)

1. Fleet Average Requirements

Fleets should perform the following steps to determine where they stand with respect to the fleet average requirements. A spreadsheet tool is already available on the ARB website to assist in performing these calculations (ARB, 2007). Staff plan to improve this tool to assist fleets in determining the lowest cost options to comply. The following provides an explanation of the steps that would otherwise be required to determine compliance strategies:

1. **Compile fleet data** - Determine the horsepower and model year for each affected engine in the fleet. Identify which vehicles are low-use vehicles,

dedicated snow-removal vehicles, vehicles used over half the time (but not exclusively) for agricultural operations, and vehicles used solely for emergency operations. These vehicles must be reported and labeled but may be excluded from the fleet size and compliance path determination.

2. **Determine the Fleet Average Goal (Fleet Average Target)** – (Note that these calculations are done automatically after the fleet information is entered into the ARB spreadsheet). If the fleet is subject to the NOx fleet average requirements, calculate the fleet's NOx Target and then the PM Target for each year. If the fleet is only subject to the PM requirements then determine the PM Target. The target will be different for every fleet and is dependent upon the horsepower distribution across horsepower categories. (If all of the fleets engines were in the 75 to 100 hp group the target would simply be the target shown in Table 1 of the regulation. If half of the engine horsepower is in one category and half in another, the target rate would be the average of the two target rates.) For each compliance year, the Target Rate is the sum of the horsepower times the target rate for each engine, divided by a fleet's total horsepower, as shown below:

$$\frac{\sum_{i=1}^{n} MaxHp_i \times \text{Target}_i}{\sum_{i=1}^{n} MaxHp_i}$$

The NOx target rates for large and medium fleets are found in Table 1 of the proposed regulation and the PM target rates for large and medium fleet are found in Table 2 of the regulation. The PM target rates for small fleets are found in Table 3 of the regulation. These tables can be found in Appendix A.

3. **Determine the Existing Fleet Average (Fleet Emissions Index) -** If the fleet is subject to the NOx fleet average requirements, calculate the fleet's NOx Index first, then PM Index. If the fleet is subject to the PM requirements only, then determine only the PM index. The emissions indices are the sum of the horsepower times the emission factor for each engine, divided by a fleet's total horsepower, as shown below:

$$\frac{\sum_{i=1}^{n} MaxHp_i \times EmissionFactor_i}{\sum_{i=1}^{n} MaxHp_i}$$

The NOx and PM Emission Index Factors are found in Attachment A of the regulation.

ARB staff has made an electronic fleet average spreadsheet tool available to fleets to help them perform the calculations referenced in steps 2 through 5 and to evaluate various compliance options for meeting the fleet averages (ARB, 2007).

If the fleet's NOx Index is less than or equal to the NOx Target Rate for a compliance date (i.e., March 1 of any compliance year), the fleet would meet the NOx requirements.

If the fleet's Diesel PM Index is less than or equal to the Diesel PM Target for a compliance date (i.e., March 1 of any compliance year), the fleet would meet the PM requirements.

The following example will help illustrate the procedure described above. Table VII-3 and Table VII-4 show the horsepower and model year data for a sample fleet. This is the data that would be compiled in Step 1 above. The sample fleet is a medium fleet with total horsepower of 1,581. For the sample fleet, Steps 2 to 5 above would yield the following results for the year 2010 targets:

2013 Diesel PM Target Rate	= 270 / 1,581	= 0.17 g/bhp-hr
Diesel PM Index	= 572 / 1,581	= 0.36 g/bhp-hr
2013 NOx Target Rate	= 7,623 / 1,581	= 4.8 g/bhp-hr
NOx Index	= 9,646 / 1,581	= 6.1 g/bhp-hr

The sample fleet's NOx and Diesel PM Indices exceed the target rates. Thus, the sample fleet would need to take action to bring its fleet averages down to meet the fleet average targets or would need to comply with the BACT requirements.

Table VII-3 - Example fleet average target and index calculation - PM

ID	Model Year	Max Hp	PM Index	PM Target for 2013	Max Hp x PM Index	Max Hp x PM Target
1	2003	88	1.09	0.46	96	40
2	1996	128	0.54	0.26	69	33
3	1999	265	0.40	0.16	106	42
4	1993	400	0.49	0.14	196	56
5	2006	300	0.15	0.14	45	42
6	2002	400	0.15	0.14	60	56
TOTAL		**1581**			**572**	**270**

Table VII-4 - Example fleet average target and index calculation - NOx

ID	Model Year	Max Hp	NOx Index	NOx Target for 2013	Max Hp x NOx Index	Max Hp x NOx Target
1	2003	88	6.9	5.7	607	502
2	1996	128	9.3	5.1	1190	653
3	1999	265	6.9	4.9	1829	1299
4	1993	400	8.9	4.7	3560	1880
5	2006	300	2.6	4.7	780	1410
6	2002	400	4.2	4.7	1680	1880
TOTAL		**1581**			**9646**	**7623**

Fleets can lower their emissions and move closer to the fleet average target rates by taking the following actions:

- Applying verified diesel emission control system (VDECS) retrofits to reduce PM or both PM and NOx. Only Level 2 and Level 3 VDECS retrofits are credited in the rule.
- Repowering vehicles with newer, cleaner engines.
- Replacing vehicles with newer vehicles that have newer, cleaner engines.
- Reducing the use of dirtier vehicles below 100 hours per year (the low-use threshold) so that such vehicles are considered low-use vehicles.

In any year, fleets may choose to either meet the fleet average requirements or meet the BACT requirements, which are discussed further below.

The proposed regulation allows electric and alternative fuel vehicles that replace diesel vehicles to be counted in the fleet average. The regulation provides criteria for demonstrating that the electric or alternative fuel vehicle replaces a diesel vehicle (must serve same purpose as a diesel vehicle, must be used outdoors, etc.). For electric vehicles that replaced a diesel vehicle, the horsepower of the diesel vehicle replaced may be used as the horsepower of the electric vehicle. As illustrated in Table VII-5, electric vehicles purchased between 2009 and 2016 would count double toward the fleet index and once in the target rate calculations. Electric ground support equipment purchased prior to January 1, 2007 would count 20 percent toward the fleet average because about 20 percent of such vehicles actually replaced diesel vehicles.

Table VII-5 - Example of How An Electric Vehicle is Counted in the Index and Target Rate Calculations

ID	Model Year	Max Hp	PM Index	PM Target for 2015	Max Hp x PM Index	Max Hp x PM Target
1	2003	88	1.09	0.62	96	55
2	1996	128	0.54	0.33	69	42
3	1999	265	0.4	0.23	106	61
4	1993	400	0.49	0.18	196	72
5	2006	300	0.15	0.18	45	54
ELECTRIC	2010	128	0	0.33	0	42
*Double counting for electric**	2010	128	0	0.33	0	42
TOTAL		**1437**			**512**	**368**
*In years 2010-16, electric piece counts double in the index and once in the target rate calculations.					**0.36**	**0.25**
					Index	**Target Rate**

Under subsection (d)(1)(D), fleets also have the option of including hours of operation in the calculation of NOx index and Diesel PM Index if they have adequate hours of use records. Fleets that have some vehicles that are heavily used and some such as back-up vehicles that are more lightly used may wish to use this option and focus their control efforts on the more heavily used vehicles.

In the Topics chapter, staff provides further discussions of the following:

- Why the rule contains a fleet average option;
- Why emission standards, not certification levels, are used in calculating fleet average indices; and
- Why load factor is not included in the fleet average index calculation.

2. BACT Requirements

Subsection (d)(2) of the proposed regulation contains the BACT requirements. If fleets do not meet the fleet average requirements described above in any compliance year, they would instead be required to meet the BACT requirements. In brief, the BACT requirements would require fleets that do not meet the NOx average targets to turn over a certain percent of their total fleet horsepower and require fleets that do not meet the PM average targets to retrofit 20 percent of their total fleet horsepower. Up to 2015, the required percent turnover is 8 percent. After 2015, the required percent turnover is 10 percent.

Fleets that have phased out the dirtiest engines (Tier 0) would not be required to do any mandatory turnover of Tier 1 or newer vehicles until 2013.

Some fleets who took or are taking early action to reduce their emissions still would not meet the fleet average targets in the early years, either because they have longer-lived vehicles or because they have an older fleet. The following provisions would provide early action credit to such fleets, for such actions as:

- Early retrofits – Level 2 or 3 retrofits installed before March 1, 2009 may be counted double toward later requirements for mandatory annual retrofit requirements. This double credit for early retrofits would give fleets incentive to install retrofits early and would allow the market to ramp up production and installations of retrofit systems.
- Early repowers - Repowers to Tier 1 or better installed before March 1, 2009 may be counted toward later mandatory turnover requirements.
- Early turnover – Fleets that turned over their Tier 0 vehicles at a rate that was greater than 8 percent per year of their total horsepower between March 1, 2006 and March 1, 2009 may apply to ARB's Executive Officer for credit towards later mandatory turnover requirements.

The following vehicles would be exempt from turnover requirements:

- Vehicles less than 10 years old;
- Specialty vehicles if certain criteria are met;
- Engines equipped with the best available PM exhaust retrofit, installed within the past six years; and
- Engines meeting the Tier 4 or interim Tier 4 standards.

The following engines would be exempt from the exhaust retrofit requirements:

- Engines in vehicles less than 5 years old;
- Engines for which there is no retrofit available or for which the retrofit cannot be safely installed;
- New engines that come with a diesel particulate filter (DPF);
- Engines already retrofit with a Level 2 or 3 VDECS that was highest level at time of installation; and
- Engines retrofit with an experimental diesel emission control strategy approved by ARB's Executive Officer.

The following example illustrates how the exemptions from mandatory turnover and retrofit work. Table VII-6 below shows a medium fleet in 2015 for which all but one vehicle meets at least one of the criteria in section 2449(d)(2)(A)4. to be exempt from the turnover requirements. The NOx Index for this example fleet is 6.1 g/bhp-hr, whereas the 2015 NOx target is 4.0 b/bhp-hr. Every vehicle in the example fleet meets the criteria for exemption from BACT turnover requirements except for Vehicle 1, the 88 hp model year 2003 vehicle. Therefore, in 2015, the example fleet would need to turn over only Vehicle 1 to satisfy the NOx requirements. This vehicle represents only 4% of the fleet's horsepower, so, even though the fleet's NOx Index exceeds the NOx target, the example fleet would not be required to turn over the full 8% of horsepower. If Vehicle 2 had not been retrofit within the last 6 years, then the example fleet would be required to turn over Vehicles 1 and 2 and satisfy the full 8% turnover requirement. If Vehicle 1 met one of the criteria for exemption from turnover, for example, if it had been retrofit with highest level VDECS in the last six years, then the fleet would not be required to do any turnover in 2015.

Table VII-6 - Fleet Example Showing Exemptions from BACT Mandatory Turnover Requirements

ID	Model Year	Max hp	% of hp	Meets Exemption Criteria?
1	2003	88	4%	No, must be turned over
2	1996	128	6%	Retrofit with highest level VDECS in last 6 years
3	1999	265	12%	Retrofit with highest level VDECS in last 6 years
4	1993	400	18%	Retrofit with highest level VDECS in last 6 years
5	2006	300	13%	Less than 10 years old
6	2002	400	18%	Specialty vehicle
7	1993	400	18%	Specialty vehicle
8	2006	300	13%	Less than 10 years old
TOTAL		2281		

3. Idling

Subsection (d)(3) of the proposed regulation contains idling restrictions. The idling restrictions would take effect immediately upon the proposed regulation being certified by the California Secretary of State. In general, the idling restrictions limit unnecessary idling to five consecutive minutes.

ARB staff recognizes that there are certain situations when idling in excess of five minutes may be necessary. Therefore, the idling limit would not apply to:

- idling when queuing;
- idling to verify that the vehicle is in safe operating condition;
- idling for testing, servicing, repairing or diagnostic purposes;
- idling necessary to accomplish work for which the vehicle was designed (such as operating a crane or workover rig);
- idling required to bring the machine system to operating temperature (i.e., idling for warm-up); and
- idling necessary to ensure safe operation of the vehicle.

As of March 1, 2009, medium and large fleets would also need to have a written idling policy and make that policy available to their vehicle operators. The idling policy should make it clear that vehicles should not be idled unnecessarily for more than five minutes.

There may be other special situations when idling is necessary that are not explicitly identified in the exemptions in subsection (d)(3). In these cases, a vehicle owner may apply to ARB's Executive Officer for a waiver to allow additional idling in excess of five consecutive minutes. The Topics chapter contains a discussion of why the idling limit was set at five minutes.

4. Adding Vehicles

Subsection (d)(7) of the proposed regulation contains requirements for adding vehicles to fleets. The requirements would be as follows:

- As of March 1, 2009, fleets would not be allowed to add vehicles with Tier 0 engines.
- Between the first and final fleet average compliance dates (March 1, 2010 to March 1, 2020 for large fleets; March 1, 2013 to March 1, 2020 for medium fleets; and March 1, 2015 to March 1, 2025 for small fleets), fleets that meet the fleet average targets would not be allowed to add a vehicle that causes them to exceed the most recent fleet average target rate. In this same time period, fleets that are complying with the BACT requirements in lieu of the fleet average requirements would not be allowed to add vehicles to their fleets unless they are Tier 2 or higher and meet the relevant fleet average targets for the appropriate horsepower group.
- After the final fleet average compliance date (March 1, 2020 for large and medium fleets and March 1, 2025 for small fleets), fleets would not be allowed to add a vehicle unless it had a Tier 3, Tier 4 interim, or Tier 4 final engine. If the engine did not come new with a diesel particulate filter, it would have to be equipped with the highest level VDECS within three months of acquisition.

5. VDECS Installation and Maintenance

Subsection (d)(8) of the proposed regulation contains requirements for owners upon installation of a VDECS. Before installing a VDECS on a vehicle, the vehicle owner should read the Executive Order for the VDECS and would need to:

- Ensure that the VDECS is verified for use with the engine and vehicle, as described in the Executive Order for the VDECS;
- Ensure that use of the vehicle is consistent with the conditions of the Executive Order for the VDECS;
- Ensure that the diesel emission control strategy is installed in a verified configuration; and
- Ensure that the engine to be retrofit is tuned up so that it meets engine manufacturer's specifications prior to VDECS installation.

Subsection (d)(9) of the proposed regulation specifies that the owner of a vehicle retrofit with a VDECS would have to ensure all maintenance on the VDECS and engine is performed as required by the manufacturer of the VDECS and engine, respectively.

6. Compliance After the Final Compliance Date

Subsection (d)(10) of the proposed regulation contains requirements for after the final compliance dates (March 1, 2020 for large and medium fleets, and March 1, 2025 for small fleets). If a large or medium fleet does not meet the NOx fleet average target rate on March 1, 2020, it must continue to turn over 10 percent of its horsepower per year until it does so. Also, as of March 1, 2021 for large and medium fleets, and March 1, 2026 for small fleets, all vehicles (except low-use vehicles, vehicles with no highest level VDECS, and vehicles that came new with a DPF) must be equipped with the highest level VDECS.

F. Special Provisions and Compliance Extensions

1. VDECS Failure

The regulation would require fleets to apply exhaust retrofits, called VDECS. Subsection (e)(1) of the regulation provides certain courses of action that must be followed if the retrofits fail. The requirements vary according to whether the retrofit was still under warranty or not at the time of failure.

Under warranty – If a VDECS fails or is damaged while under warranty and it cannot be repaired, it would have to be replaced with the same level VDECS or higher.

Outside warranty – If a VDECS fails or is damaged after its warranty period and before March 1, 2021 for large/medium fleets, and March 1, 2026 for small fleets, the owner would have to replace it with the highest level VDECS available unless it can still meet the fleet average targets without it. So, if a Level 2 VDECS fails outside of warranty, it would need to be replaced with a Level 3 VDECS, unless the fleet is so clean that the VDECS is not needed to meet the fleet average targets. After March 1, 2021 for large/medium fleets, and March 1, 2026 for small fleets, any VDECS that fails outside of warranty would have to be replaced with the highest level VDECS.

2. Fuel-based Strategy VDECS

Subsection (e)(2) of the proposed regulation contains special provisions that would allow a fleet to use a Level 2 fuel based strategy across its whole fleet if the highest level VDECS for a large portion of its fleet would be Level 2. The rule also contains special provisions that would give an extension to fleets that use a fuel-based strategy but find that it has been discontinued.

3. Vehicles Used for Emergency Operations

Under subsection (e)(3) of the proposed regulation, vehicles used solely for emergency operations would be exempt from the performance requirements of the rule, but still must be labeled and reported. For vehicles used both for emergency operations and for other purposes, hours of operation accrued when the vehicle is used for emergency operations would not need to be included when determining whether the vehicle meets the low-use vehicle definition.

4. Use of Experimental Diesel PM Emission Control Strategies

Under subsection (e)(5) of the proposed regulation, an owner could apply to the Executive Officer to use of an experimental, or non-verified, diesel PM control strategy if a VDECS is not available or if the owner can demonstrate that an existing VDECS is not feasible for their vehicle or application, or if use of the non-verified strategy is needed to generate data to support verification of the strategy.

5. Compliance Extension for Equipment Manufacturer Delays

Under subsection (e)(6) of the proposed regulation, fleet owners would not be penalized for equipment manufacturer delays for vehicles, engines, or VDECS. As long as the owner placed the order for the required equipment or vehicle at least six months prior to the required compliance date, for purposes of regulation enforcement, the equipment or vehicle will be treated as if it is place. The new equipment or vehicles would, however, need to be immediately placed into operation upon receipt.

6. Exemption for Low-Use Vehicles

Under subsection (e)(7) of the proposed regulation, low-use vehicles would not be subject to the compliance requirements (i.e., would not be counted in the fleet average and would be exempt from the BACT requirements). Low-use vehicles also would not need to be included in the sum of maximum power when determining fleet size.

7. VDECS That Impairs Safe Operation of Vehicle

Under subsection (e)(8) of the proposed regulation, a fleet owner may request that the Executive Officer find that a VDECS should not be considered the highest level VDECS available because it cannot be safely installed or operated in a particular vehicle application. The requesting party would have to provide documentation to support its claims that the VDECS cannot be safely installed or operated. Documentation would have to include reports and findings of federal, state or local government agencies, independent testing laboratories, engine or equipment manufacturer studies, or other equally reliable source. The Executive Officer would review the documentation submitted and make his or her determination based upon the totality of the evidence. The Executive Officer would send a written determination letter to the requesting party within 60 days of the request being submitted.

8. Compliance Flexibility for Delay of Tier 4 Interim or Final Vehicles

Under subsection (e)(9) of the proposed regulation, the Executive Officer could grant delays to a fleet or group of fleets if there are delays in the availability of vehicles with Tier 4 interim or final engines.

G. Labeling

As described in subsection (f) of the proposed regulation, the regulation would require that each vehicle subject to the requirements of the regulation be labeled with a unique ARB-issued equipment identification number (EIN). This EIN will allow inspectors to know that the vehicle has been reported to ARB and to match up and verify data reported on the vehicle (such as model year, engine information, and type of retrofit).

ARB will issue the initial batch of EINs in response to the initial rounds of reporting in 2009. If new vehicles are purchased or brought into California after the initial reporting, the fleet owner would have 30 days from the date of purchase or entry into California to apply to ARB for an EIN. Within 30 days of receipt of the EIN, the fleet owner would have to permanently affix or paint the EIN on the vehicle on the right side about five feet above the ground.

The fleet owner may choose the best method for affixing the EIN, but it must be kept legible for the life of the vehicle. Some owners may choose to paint the EIN on vehicles. Others may affix a plate to the side of the vehicle or attach a sticker.

The regulation spells out specifications for where the EIN must be placed and how big it must be. The EIN will be white on a red background. Figure VII-6 shows a mock-up for how the EIN would look on a scraper.

Figure VII-6 - Mock-up of how Equipment Identification Number Would Appear on a Scraper

H. Reporting

Because of the fleet average requirements of the proposed regulation and because the BACT requirements include a gradual phase-in of turnover and retrofitting, accurate and effective enforcement of the proposed regulation will depend on ARB getting an accurate depiction of the entire fleet of each fleet owner. That is, an inspector will not be able to gauge compliance by looking at any one vehicle. For example, an inspector could not assume that all scrapers such as that pictured in Figure VII-6 would be a certain tier or have a certain VDECS as of a certain date. Thus, accurate reporting will be essential. To this end, the reporting requirements in subsection (g) of the regulation are thorough.

All fleets would need to do initial reporting in 2009. In the initial reporting, all fleets would have to report their fleet as it was on March 1, 2009. Reporting dates are staggered based on fleet size. Large fleets would have to report by April 1, 2009. Medium fleets would have to report by June 1, 2009. Small fleets would have to report by August 1, 2009.

In the initial reporting, fleets would need to report a list of each vehicle subject to this regulation, along with the following information for each vehicle:

- Vehicle type;
- Vehicle manufacturer;
- Vehicle model;
- Vehicle model year;
- Whether the vehicle is a low-use vehicle;
- Whether the vehicle is a specialty vehicle;
- Whether the vehicle is a dedicated emergency vehicle;
- Whether the vehicles is a dedicated snow removal vehicle;
- Whether the vehicle is used for agricultural operations for over half its annual operating hours;
- Whether the vehicle is an electric vehicle that replaced a diesel vehicle;
- Whether the vehicle is one that the owner intends to retire within one year; and
- For each engine that propels the vehicle, the engine manufacturer, engine family, engine serial number, engine model year, engine maximum horsepower, type of retrofit emission control equipment installed (if any), date installed, and its verification level.

Once the initial reporting is complete, fleets would need to annually report any changes since the last reporting. Changes that must be reported include adding vehicles, removing vehicles from the fleet, designating vehicles as low-use vehicles, repowering of vehicles, or retrofitting vehicles. Along with the annual reporting, fleets also must submit a certification from a responsible official that the information reported is accurate and that the fleet is in compliance with the regulation.

To ease reporting, staff intends to develop and provide electronic reporting forms via the internet for both the initial and annual reporting requirements. Fleets that prefer would be able to report via hard-copy. Staff plans to conduct outreach to fleet owners to explain and clarify these reporting requirements.

I. Recordkeeping

Subsection (h) of the proposed regulation describes recordkeeping requirements. Fleet owners would have to maintain copies of the reporting information described above. Fleet owners would also need to maintain information on any changes that have occurred since the last reporting period. For example, if a fleet adds a new vehicle, it has 30 days to apply for a label. If an inspector views a fleet in the interim period before the fleet has applied for a label and finds a vehicle for which a label has not yet been requested, the fleet would have to be able to demonstrate when the vehicle entered the fleet. Fleets could make this demonstration by presenting vehicle purchase records or shipping records. Records must be retained for as long as an owner has a fleet or until 2030.

J. Right of Entry

Subsection (i) of the proposed regulation states that ARB inspectors would have the right to enter any facility where off-road vehicles are located or off-road vehicle records are kept in order to inspect off-road vehicles and their records. Inspectors would need to first obtain any necessary safety clearances and present proper credentials.

K. Disclosure of Regulation Applicability

Subsection (j) of the proposed regulation would impose a responsibility on sellers of off-road vehicles that are potentially subject to the regulation to inform buyers of that. The purpose of the disclosure provision is to ensure that fleets are aware of potential future retrofit, repower, or replacement requirements before they make the decision to buy a vehicle.

Any person selling a vehicle with an engine subject to this regulation in California would be required to provide the following disclosure in writing to the buyer on the bill of sale:

> "When operated in California, any off-road diesel vehicle may be subject to the California Air Resources Board In-Use Off-road Diesel Vehicle Regulation. It therefore could be subject to retrofit or accelerated turnover requirements to reduce emissions of air pollutants. For more information, please visit the California Air Resources Board website at http://www.arb.ca.gov/msprog/ordiesel/ordiesel.htm."

L. Penalties

Subsection (k) of the proposed regulation describes the penalty provisions. The maximum penalties are as specified in sections 39674, 39675, 42400, 42400.1, 42400.2, 42402,.2, and 43016 of the Health and Safety Code. In assessing penalties, the Executive Officer will consider the willfulness of the violation, the length of time of noncompliance, whether the fleet made an attempt to comply, and the magnitude of noncompliance.

M. References

ARB, 1990. California Air Resources Board. Assessment and Mitigation of the Impacts of Transported Pollutants on Ozone Concentrations within California, Staff Report, June 1990.

ARB, 1993. California Air Resources Board. Assessment and Mitigation of the Impacts of Transported Pollutants on Ozone Concentrations in California, Staff Report, June 1993.

ARB, 1996. California Air Resources Board. Second Triennial Review of the Assessment of the Impacts of Transported Pollutants on Ozone Concentrations in California (Revised), November 1996.

ARB, 2001. California Air Resources Board. Assessment of the Impacts of Transported Pollutants on Ozone Concentrations in California, March 2001. http://www.arb.ca.gov/regact/trans01/isor.pdf

ARB, 2007. California Air Resources Board Fleet Average Calculator Spreadsheet Tool. Posted January 16, 2007. http://www.arb.ca.gov/msprog/ordiesel/documents.htm

VIII. TECHNOLOGICAL FEASIBILITY OF CONTROL MEASURE

The proposed regulation would require off-road fleets to reduce diesel emissions below the level that would be achieved as older vehicles are normally retired and newer, cleaner vehicles are purchased (natural turnover). The strategies available for reducing diesel emissions from in-use off-road vehicles beyond natural turnover include retrofitting exhaust aftertreatment devices on existing engines, repowering a vehicle (i.e., replacing an existing engine with a newer and cleaner engine), or replacing the vehicle and engine with a newer, cleaner vehicle and engine at rates higher than natural turnover. Additional information on the variety of emission reduction options for diesel fueled engines is provided in the Diesel Risk Reduction Plan (ARB, 2000).

Reducing emissions from diesel engines is an area of active research and development. Engine manufacturers are developing technologies to reduce PM and NOx emissions to meet future California and federal engine exhaust standards. In addition to technologies to reduce emissions in new engines, the fields of retrofitting with exhaust aftertreatment devices and engine repowering are growing rapidly, spurred both by the research and development ongoing for new engines, and by California's air toxic control measures for in-use diesel fleets. Based on its evaluation of the technology available today and an assessment of technology likely to be available in the near future, staff is confident that the proposed control measure is technologically feasible.

The following sections describe the availability of ultra-low sulfur diesel fuel, verification of diesel emission control strategies, various diesel emission control strategies available today, a list of ARB verified devices, a summary of off-road rules requiring retrofits, a summary of current off-road installations of PM retrofits, and the availability of repower and replacement off-road vehicles.

A. Availability of Ultra-low Sulfur Diesel Fuel

Many diesel emission control strategies (DECS) are adversely affected by sulfur in diesel fuel. In particular, sulfur can affect DECS by inhibiting the performance of catalytic materials. This phenomenon, known as catalyst "poisoning", not only adversely affects the ability of the DECS to reduce emissions, but can also lead to greater soot accumulation on a DECS which may reduce engine performance. Diesel fuel sulfur can also compete with chemical reactions within DECS intended to reduce pollutant emissions and create particulate matter through sulfate formation. The availability of ultra low-sulfur fuel enables DECS to be designed for improved emission control performance, as well as to reduce sulfate emissions. Ultra-low sulfur (15 parts per million by weight (ppmw) or less sulfur content) diesel fuel is therefore required for effective functioning of many DECS (MECA, 2005).

California's diesel fuel regulations mandated the supply of ultra-low sulfur diesel fuel at retail stations for on- and off-road use beginning September 1, 2006. For states outside of California, the U.S. EPA's on-road diesel fuel standards mandate a phase-in of ultra-low sulfur fuel supplied at retail stations beginning October 15, 2006. For off-road applications (other than marine and locomotive), U. S. EPA has established diesel fuel standards requiring diesel fuel sold beginning October 1, 2007, must be low sulfur, with a maximum sulfur content of 500 ppmw. By October 15, 2010, all on-road and off-road diesel fuel (other than locomotive and marine) must be ultra-low sulfur fuel.

When the regulation is implemented for large fleets in 2010, ultra-low sulfur diesel fuel will be available for both a DECS equipped off-road vehicle operating in California, as well as for a vehicle that may be stored or operated out-of-state and then used in California.

B. Verification of Diesel Emission Control Strategies

1. ARB's Diesel Emission Control Strategies Verification Program

Verification is an approval from ARB which assures end users that a verified retrofit device achieves its advertised emission reductions and is durable (based on in-use field testing ARB adopted a procedure to verify retrofit DECS in 2003 (title 13, CCR, sections 2700 et seq.). A retrofit DECS is a device that is installed onto an in-use engine to reduce emissions for that engine, is not part of the new engine certification program, and is not covered through the new engine or emission warranty from the engine manufacturer. The purpose of the verification procedure is to verify strategies and systems that reduce diesel PM emissions from in-use engines.). Under the verification program, the device manufacturer is required to provide a warranty against engine damage caused by the DECS. The minimum warranty period for off-road devices is listed in Table VIII-1. To protect the end user, only ARB-verified DECSs can be used in all of ARB's mandated and most of its voluntary retrofit programs.

Table VIII-1 - Diesel Emission Control Strategy Warranty Period

Engine Size	Minimum Warranty Period
At or above 25 hp and under 50 hp	4 years or 2,600 hours
At or above 50 hp	5 years or 4,200 hours

ARB's verification procedure is a multi-level verification program consisting of three PM reduction levels and optional NOx reduction levels (Table VIII-2). Reductions in NOx are not required for verification, but ARB's procedure recognizes and verifies NOx reductions that are greater than or equal to 15 percent in five percent increments. To be eligible for verification, devices which achieve NOx reductions must also achieve PM reductions. The verification program has broadened both the spectrum of control technologies available for use in California's diesel emission control effort and the number and types of vehicles and engines that can be controlled. This multi-level approach to verification is consistent with the goal of achieving the maximum reductions in diesel PM emissions that are economically and technologically feasible. At this time, nearly all the verified emissions control strategies are retrofit exhaust aftertreatment devices.

Table VIII-2 - Diesel Emission Control Strategy Verification Levels

Category	PM Reduction
Level 1	≥ 25 %
Level 2	≥ 50 %
Level 3	≥ 85 %, or 0.01 g/bhp-hr
Category	**NOx Reduction**
Not verified	<15 %
Optional	≥ 15 %; in 5 % increments

The verification procedure requires considerable data to demonstrate emission reductions and durability, and any DECS that uses a fuel additive must demonstrate that it is non-toxic in all media by going through a multimedia assessment. The list of ARB verified devices is given in subsection D.

2. United States Environmental Protection Agency's (U. S. EPA's) Voluntary Diesel Retrofit Program

The U.S. EPA has also established its own Voluntary Diesel Retrofit Program, which also verifies DECS using criteria which are similar to the ARB's verification program. To facilitate the exchange of information between programs, ARB and U.S. EPA signed a Memorandum of Agreement (MOA) for the Coordination and Reciprocity in Diesel Retrofit Device Verification. The MOA establishes reciprocity in verifications of hardware or device-based retrofits, and further reinforces U.S. EPA's and ARB's commitment to cooperate on the evaluation of retrofit technologies. Under the MOA, U.S. EPA and ARB are committed to work toward accepting PM and NOx verification levels assigned by the other's verification programs. Additionally, as retrofit manufacturers initiate and conduct in-use testing, U.S. EPA and ARB agreed to coordinate this testing so data generated may satisfy the requirements of each program. This MOA is intended to expedite the verification and introduction of innovative emission reduction technologies. Additionally, this MOA should reduce the effort needed for retrofit technology manufacturers to complete verification. More information on the U.S. EPA's Voluntary Diesel Retrofit Program can be found at http://www.epa.gov/oms/retrofit/retrofittech.htm.

3. European References to the VERT List

Various Swiss, German, Swedish, and other European rules and standards requiring DECS on off-road vehicles reference verifications performed by the Verminderung der Emissionen von Real-Dieselmotoren im Tunnelbau (VERT). The English translation is "Reduction of diesel-emissions in tunneling". For their part in supporting European verifications, VERT has established a list (VERT list) of DECS that meet established emission reductions and durability criteria. (Links to the VERT list can be found in Table VIII-1.) These criteria were established under the VERT "Curtailing Emissions from Diesel Engines in Tunnel Construction" program, a research program conducted from

1994 to 2000, and sponsored by Swiss, German, and Austrian occupational health authorities. The VERT list is maintained and updated by BUWAL (Bundesamt für Umwelt, Wald und Landschaft - Swiss Agency for the Environment, Forests and Landscape) and by SUVA (Schweizerische Unfallversicherungsanstalt - Swiss National Accident Insurance) (AKPF, 2006).

C. Diesel Emission Control Strategies

1. Retrofits

A variety of retrofit strategies can be used for controlling emissions from in-use diesel engines (Diesel Forum, 2006). The main types of technologies discussed here are add-on hardware, additives, and combinations of hardware and additives. The hardware retrofit technologies that are most likely to be employed, i.e., diesel particulate filters (DPFs) and flow-through filters (FTFs), are retrofitted onto the exhaust pipes downstream of the engine. Additive based systems reduce emissions by introducing an additive into the fuel, air, or exhaust depending on the type of additive. Combinations of hardware and additives could include a device retrofitted to the exhaust system and an additive introduced into the fuel stream; or, in the case of selective catalytic reduction (SCR) the hardware is installed on the exhaust system and the additive is introduced into the exhaust stream before the hardware. These technologies are discussed in more detail below.

Technical suitability of a particular type of DECS will depend on the engine and vehicle to be retrofit. Technical considerations include space constraints inside the engine compartment, operator visibility, weight of the DECS, vibration, backpressure, and exhaust temperatures (MECA, 2003).

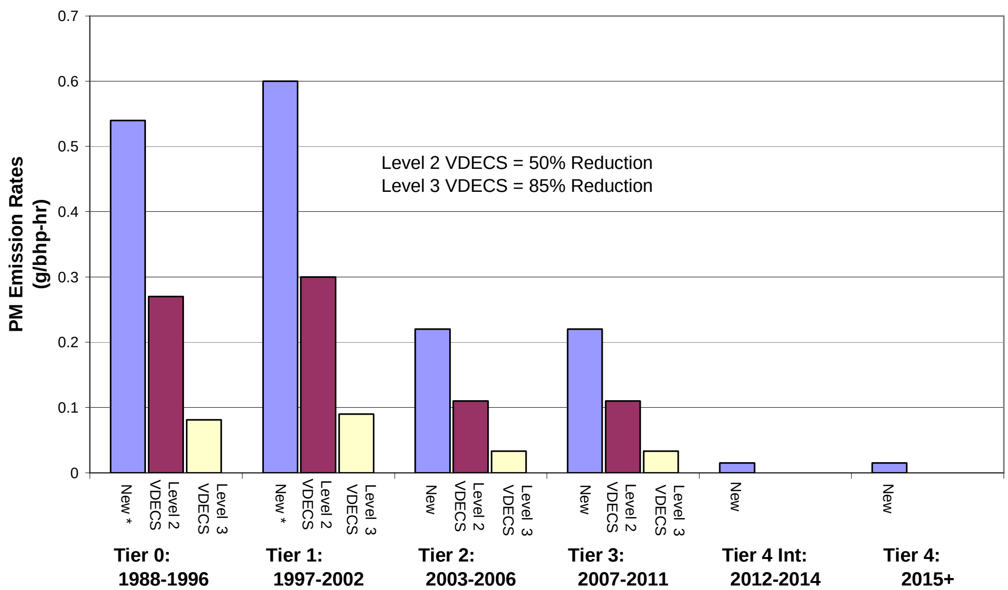
The financial suitability of a DECS (discussed in more detail in Chapter 11) will vary depending on the type of DECS and the horsepower of the engine being retrofitted. In general, a Level 3 DECS that is more effective in reducing PM and NOx emissions will be more expensive than a Level 2 DECS that is less effective at reducing emissions.

Large and small horsepower engines may encounter different technical and financial issues. For example, higher horsepower engines typically require DECS that are more expensive than lower horsepower engines and for very large engines two devices in parallel (dual) may be required to avoid excessive backpressure and allow sufficient exhaust flow. While a dual retrofit is a technical solution, costs and mounting complexity increase. On the other hand, retrofitting smaller horsepower engines may present other issues, such as small engine compartment size as well as a less favorable cost per horsepower than larger engines.

However, retrofitting even small engines is a feasible option for complying with the proposed regulation. The transport refrigeration units (TRU) regulation adopted by the ARB in 2003 has similar challenges in retrofitting small diesel engines, with TRU engines typically ranging from 9 to 36 horsepower.

A particular engine's contribution to the Diesel PM index and NOx index, which are used in the proposed rule for tracking compliance with the fleet average requirements, will vary depending on the emission standard to which the engine is certified, and the verified level of the retrofit device if installed. As an example, Figure VIII-1 shows PM emission rates for new and retrofitted 100-174 horsepower off-road engines.

Figure VIII-1 - PM Emission Rates for New and Retrofitted Off-Road Engines 100-174 HP



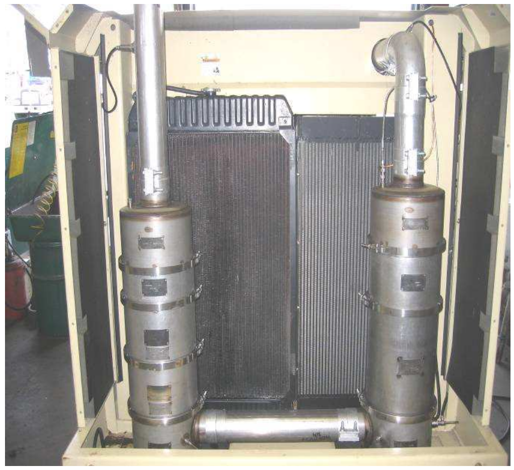
* - Estimated emission rate is shown because standards did not exist for this pollutant at that time.

The following photos in Figure VIII-2 demonstrate the wide variety of applications and installations possible for DPFs. The DPFs are circled in the photos.

Figure VIII-2 - Photos of DPF Installations on Construction Vehicles

A Combination DPF and SCR system mounted on an air compressor shown in Figure VIII-3.

Figure VIII-3 - Photo of a Combination DPF and SCR System



a) Hardware Diesel Emission Control Strategies

There are a number of hardware diesel emission control strategies available to reduce diesel PM emissions from in-use diesel vehicles, including DPFs and flow through FTFs. Some DPFs also reduce CO and HC emissions through catalytic oxidation and filtration. Most DPFs sold in the United States use substrates consisting either of a ceramic wall-flow monolith or a silicon carbide substrate. These substrates are either coated with a catalyst material, typically a platinum group metal, or a separate catalyst is installed upstream of the particulate filter. The filter is positioned in the exhaust stream to trap or collect a significant fraction of the particulate emissions while allowing the exhaust gases to pass through the system.

Effective operation of a DPF requires a balance between PM collection and PM oxidation, or regeneration. The volume of PM generated by a diesel engine will fill up (load) a DPF over time; thus the trapped PM must be burned off or "regenerated" periodically. Regeneration is accomplished by either raising the exhaust gas temperature or by lowering the PM ignition temperature through the use of a catalyst. In contrast, flow-through filters (FTF) employ a catalyzed wire mesh substrate that has an intermix of flow channels creating turbulent flow conditions.

(1) Passive Diesel Particulate Filter (Passive DPF)

The type of filter technology that uses a catalyst to lower the PM ignition temperature is termed a passive DPF, because no outside source of energy is required for regeneration. Verified passive DPFs have demonstrated reductions of at least 85 percent for PM, and have verified as Level 3 devices. A passive catalyzed DPF also reduces CO and HC by approximately the same amount as the PM reduction. A passive catalyzed DPF is an attractive means of reducing diesel PM emissions on certain engines and duty cycles because of the combination of high reductions in PM emissions and minimal operation and maintenance requirements. However, passive DPF systems can increase emissions of NO_2 out of the tailpipe. To address this, the ARB verification program limits the amount of NO_2 a DECS may create.

Several passive DPF systems have been verified in California for on-road use on a variety of diesel applications, including the most popular engine series of the major engine manufacturers for model-year engines 1993 to 2004. However, as of February 2007, there are no California-verified passive DPF systems for off-road applications. Due to the variety of duty cycles experienced in off-road applications, i.e., the variety of engine rpm and torques, at low engine load, the exhaust temperature may be too low in some off-road vehicles to adequately burn off accumulated PM on a passive DPF. Also, older dirtier engines that were not subject to emission control standards when they were new may have PM emissions that exceed the ability of a passive device to burn off during regeneration.

There is a U.S. EPA verified passive DPF which achieves Level 3 PM reductions from off-road engines, the Caterpillar DPF. The Caterpillar DPF has been verified for nonroad, 4-cycle, non-EGR equipped, model year 1996-2005, turbocharged engines with power ratings of approximately 175 horsepower to 300 horsepower. Caterpillar has indicated there is a negligible (approximately 1 percent) fuel economy penalty with the use of this technology. More information on the Caterpillar DPF can be found at: http://www.epa.gov/oms/retrofit/retroverifiedlist.htm.

(2) Active Diesel Particulate Filter (Active DPF)

Unlike a passive DPF, an active DPF system uses an external source of heat to oxidize the accumulated PM. The most common methods of generating additional heat for oxidation involve electrical regeneration by passing a current through the filter medium, injecting and burning additional fuel to provide additional heat for particle oxidation, or adding a fuel-borne catalyst or other reagent to initiate regeneration. Some active DPFs induce regeneration automatically on-board the vehicle or equipment when a specified backpressure is reached. Others use an indicator, such as a warning light, to alert the operator that regeneration is needed, and require the operator to initiate the regeneration process. Some active systems collect and store diesel PM over the course of a full shift and are regenerated at the end of the shift with the vehicle or equipment shut off. A number of the filters are removed and regenerated externally at a regeneration station.

For applications in which the engine-out PM is relatively high, and/or the exhaust temperature is relatively cool, actively regenerating systems may be more effective than a passive DPF. Because active DPFs are not dependent on the heat carried in the exhaust for regeneration, they potentially have a broader range of application than passive DPFs.

As of February 2007, ARB has verified three active DPFs that can be used in off-road applications. Full verification has been given to the Engine Control System (ECS)

Combifilter for certain off-road applications and the HUSS Umwelttechnik FS-MK for most on-road and off-road applications. Both systems utilize a silicone-carbide wall flow filter. The ECS Combifilter is regenerated via an electrically-heated regeneration system (i.e. plug-in) whereas the HUSS FS-MK device uses an on-board fuel burner to provide additional heat necessary for regeneration. These devices are not currently verified for engines equipped with either diesel oxidation catalysts (DOC) or exhaust gas recirculation systems. A conditional verification has been given to the Cleaire Horizon Electric Particulate Filter for use with all off-road diesel engines through the 2007 model year certified to a particulate matter emission level equal to or less than 0.4 grams per brake horsepower-hour and having displacements of up to 15 liters, except those equipped with either DOCs or exhaust gas recirculation systems. The Horizon uses a silicon carbide wall-flow filter with an electric heater for regeneration.

The ARB Executive Orders (EO) include any restrictions for these verifications, and a list of applications and engine families for which the device has been approved. These three EOs are:

- Engine Control System Combifilter Executive Order DE-04-012, dated December 13, 2004 (EO DE-04-012, 2004).
- HUSS Umwelttechnik FS-MK Executive Order DE-06-006, dated November 13, 2006 (EO DE-06-006, 2006).
- Cleaire Horizon Electric Particulate Filter Executive Order DE-05-010 dated February 14, 2007 (EO DE-05-010-02, 2007).

(3) Catalyzed Wire Mesh Flow Through Filter (FTF)

Unlike a DPF, in which only gases can pass through the substrate, the FTF does not physically trap and accumulate PM as effectively. Instead, it primarily relies on reducing emissions through catalytic oxidation alone. Consequently, the filtration efficiency of an FTF is lower than that of a DPF, but the FTF is much less susceptible to plugging because of high PM emissions and low exhaust temperatures. Therefore, this type of filter may be suitable for specific off-road duty cycles where a typical DPF might not be applicable; however, as of April 2007, no FTF has been verified for off-road applications.

The ARB has verified the Donaldson flow-through filter for diesel engines used in on-road applications operating on 15 ppm sulfur diesel fuel. The Donaldson system uses a two-stage metallic filter to trap and reduce PM. Each filter stage consists of alternating layers of a corrugated metal and a porous sintered metal fleece with a catalyst coating. The Donaldson FTF achieves at least a 50 percent reduction in particulate matter emissions, qualifying it for a Level 2 verification. The Donaldson system has not been approved for off-road applications.

b) Additive Diesel Emission Control Strategies

Additive DECS utilize a substance, other than diesel fuel, which is added during the operation of the vehicle, either pre-combustion or post-combustion, to reduce diesel exhaust emissions. Pre-combustion additives include fuel-based and intake air-based additives that utilize the fueling system or air intake systems, respectively, to introduce an additive. Post-combustion additives include exhaust-based additives that introduce an additive directly into the exhaust system to reduce exhaust emissions. Most additive systems are designed to work in conjunction with a hardware component and will be offered as a combined hardware and additive system as discussed in the next subsection.

Additive DECS must undergo an assessment of multimedia toxicity effects by the California Environmental Policy Council as required by Health and Safety Code 43830.8 prior to ARB verification.

(1) Fuel-Water Emulsion

A demonstrated alternative to diesel fuel that reduces both PM and NOx emissions is an emulsion of diesel fuel and water. The process blends water into diesel fuel, along with an emulsion additive to keep the mixture from separating. The water is suspended in droplets within the fuel, creating a cooling effect on the fuel that decreases NOx emissions. Also, a fuel-water emulsion creates a leaner fuel environment in the engine, thus lowering PM emissions as well (U.S. EPA 2002).

ARB has verified Lubrizol ECS's PuriNox for 1988 through 2003 MY diesel engines used in on-road applications (EO DE-04-008, 2004) as an alternative diesel fuel. PuriNOx™ is an emulsified diesel fuel that achieves at least 50 percent reduction in PM and 15 percent reduction of NOx and is categorized as a Level 2 system. Lubrizol requires fleets that use PuriNOx™ to install a recirculation pump in the products' storage tank, and vehicles fueled with product must be used on a daily basis.

While PuriNOx™ is currently verified, as of the end of 2006 it is no longer marketed in California. It is, however, possible that another company could acquire rights to sell Lubrizol in California in the future (Brown, 2006).

(2) Fuel Additives

A fuel additive, such as a fuel-borne catalyst, is a substance designed to be added to fuel or fuel system so that it is present in-cylinder during combustion and its addition causes a reduction in exhaust emissions. Additives can reduce the total mass of PM, with variable effects on carbon monoxide, NOx, and gaseous hydrocarbon production. The range of PM reductions that have been published in studies of fuel additives is from 15 to 50 percent reduction in mass. Most additives are fairly insensitive to fuel sulfur content and will work with a range of sulfur concentrations as well as different fuels and other fuel additives (ARB, 2003). No fuel additive is currently verified by ARB.

c) Combinations of Hardware and Additive Diesel Emission Controls Devices

While not currently verified in California, systems combining hardware and an additive strategy are in-use in other parts of the world. In order to receive ARB verification, the hardware and additive strategy must be approved together as a system.

(1) Fuel-Borne Catalyst (FBC)

A fuel-borne catalyst (FBC) is a substance that is added to diesel fuel in order to aid in soot oxidation in DPFs by decreasing the ignition temperature of solid carbon. An FBC can be used in conjunction with both passive and active filter systems to aid system performance, and decrease mass PM emissions. FBC/DPF systems are in widespread use in Europe in both on-road and off-road, mobile and stationary applications and typically achieve a minimum of 85 percent reduction in PM emissions. The ARB has not verified any system using an FBC as of April 2007.

The U.S. EPA has verified two combination systems under its voluntary program. Clean Diesel Technologies, Inc. manufactures the two U.S. EPA verified products. One is the Platinum Plus Purifier System, which is a fuel borne catalyst plus DOC verified for on-road, medium-heavy and heavy-heavy duty, 4 cycle, 1988 – 2003 MY, turbocharged or naturally aspirated engines. The other is the Platinum Plus Fuel Borne Catalyst/Catalyzed Wire Mesh Filter (FBC/CWMF) System, which is verified for on-road, medium-heavy duty, 4 cycle, 1991 to 2003 MY, non-EGR, turbocharged or naturally aspirated engines. The U.S. EPA does not assign a level for PM reduction as California does, but describes the fuel-borne catalyst plus DOC as achieving 25 to 50 percent PM reduction and the fuel-borne catalyst plus wire mesh filter as achieving 55 to 76 percent PM reduction. Because these systems use a fuel additive, they would need to undergo a multimedia assessment prior to receiving ARB verification.

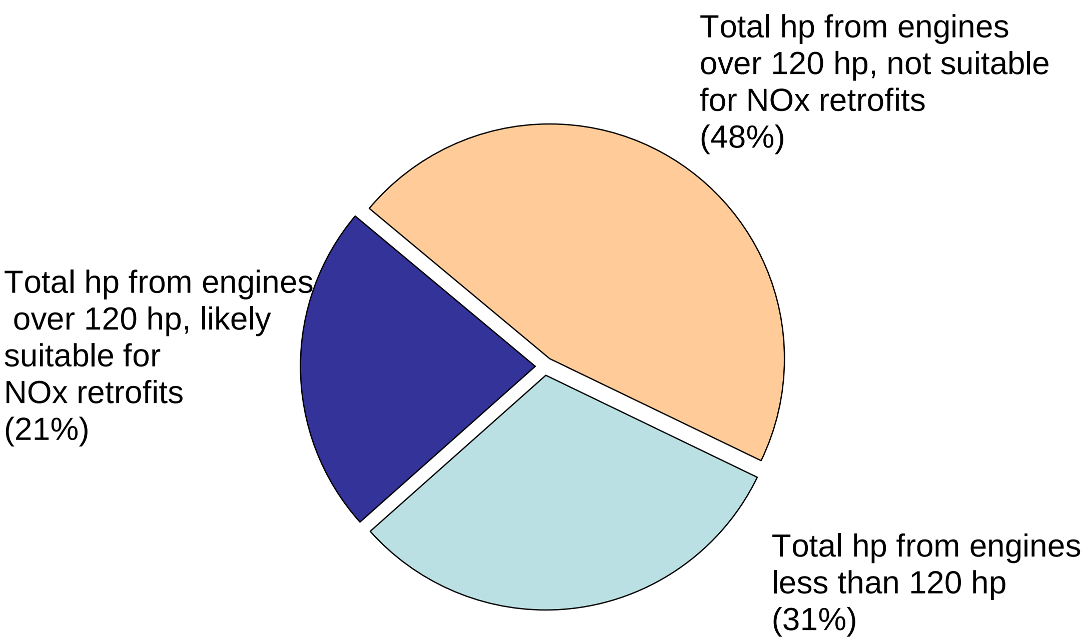
(2) Selective Catalytic Reduction (SCR)

A SCR system injects ammonia or urea into the diesel exhaust stream which then reacts over the catalyst bed with the NOx in the exhaust to produce water and nitrogen, thus reducing the diesel exhaust NOx. Although not as widely applicable as retrofit DPFs, SCR systems may be suitable for certain retrofit applications. SCR systems have been used for stationary source NOx control for a number of years, as SCR systems are easier to control for relatively steady-state conditions. More recently, SCR systems have been developed for more challenging mobile source applications. SCR systems have recently been a component on some new on-road vehicles in Europe. SCR systems are just now emerging as a retrofit option. Most manufacturers are expected to develop systems for on-road retrofit prior to developing those for off-road, because off-road applications are more challenging and costly.

Staff has evaluated the potential penetration of retrofit SCR systems in off-road application, and does not believe that a significant number of vehicles could ultimately be retrofitted with SCR systems.

Engines with less than 120 horsepower are not likely to be appropriate for use of NOx exhaust retrofit systems because of engine compartment size limitations, and the costs for such systems relative to engine replacement options. The remaining engines greater than 120 hp in the fleet are potential candidates for SCR systems. However, exhaust temperatures (or duty cycle limitations) will likely dictate the actual suitability of certain vehicles to use SCR or other NOx-control technologies. In general, SCR systems need to operate in temperature regimes similar to those required for passive DPF systems. Staff estimates that only about 30 percent of off-road vehicles would have exhaust temperature characteristics suitable for passive DPF systems (ARB, 2006). Therefore, staff believes between 20 and 25 percent of the off-road vehicles could be suitable for the use of a combined DPF/SCR system retrofit. This is shown in Figure VIII-4 below.

Figure VIII-4 - Percent of Off-Road Engines Suitable for NOx Retrofits



The ARB has verified one SCR-based system for off-road engines, the Extengine Advanced Diesel Emission Control (ADEC) system, for 1991 to 1995 model year off-road Cummins 5.9-liter diesel engines from 150 to 200 horsepower. These are engines which are used in excavators, dozers, and loaders, all with rubber tires, and utility tractor rigs operating on standard CARB or ultra low sulfur diesel fuel. The ADEC system employs a DOC, SCR catalyst, and an ammonia slip catalyst to achieve a 25 percent reduction in particulate matter emissions, qualifying it for Level 1 verification (and therefore not eligible for credit under the proposed regulation). The system also achieves an 80 percent reduction in NOx emissions.

D. List of ARB Verified Technologies

ARB has received over one hundred applications for verification, but not all of those applications are active. The procedure requires considerable data to prove emission reductions and durability. Any DECS that uses an additive must also demonstrate that it is non-toxic in all media by going through a multimedia assessment. As of April 6, 2007, ARB has verified the DECS shown in the tables below. The verified Level

3 devices are shown in Table VIII-3, and the Level 2 devices are shown in Table VIII-4. Although the proposed regulation does not accept Level 1 device for compliance purposes, Level 1 devices are shown in Table VIII-5 for completeness of the retrofit device discussion. The off-road verified DECS are shaded in the tables.

Table VIII-3 - Verified Level 3 DECS (as of April 6, 2007)

Product Name	Technology Type	PM Reduction	NOx Reduction	Applicability
Cleaire Horizon	DPF	85%	N/A	Most on-road engines; 15 ppm sulfur diesel; CARB diesel, conditionally verified for off-road engines
Cleaire Longview	Lean NOx Catalyst and DPF	85%	25%	1993-2003 model year on-road; 15 ppm sulfur diesel.
CleanAIR Systems PERMIT	DPF	85%	N/A	Stationary emergency and prime generators; 15 ppm sulfur diesel.
Donaldson DPM	DPF	85%	N/A.	1993-2004 on-road; 15 ppm sulfur diesel.
HUSS Umwelttechnik FS_MK	DPF	85%	N/A	Most on-road and off-road diesel engines through 2007 model year.
International Truck and Engine Corporation DPX	DPF	85%	N/A.	1994-2003 on-road Navistar (International); 15 ppm sulfur diesel.
Johnson Matthey CRT	DPF	85%	N/A.	Stationary emergency and prime generators. Conditionally verified for stationary pumps.
Johnson Matthey EGRT	EGR/DPF	85%	40%	2000 International DT-466, 2000 Cummins ISM 2001 Cummins ISB, 1998-2002 Cummins ISC, 2001 Cummins ISL, 2001 MY DDC - 50, and 2001 DDC - 60. on-road; 15 ppm sulfur diesel.
Engine Control System Purifilter	DPF	85%	N/A	1994-2003 on-road; 15 ppm sulfur diesel.
Engine Control System Combifilter	DPF	85%	N/A	1996-2004 off-road; 15 ppm sulfur diesel; CARB diesel.
MIRATECH Corporation combiKat	DPF	85%	N/A	Stationary emergency and prime generators with a PM emission rate of 0.2 g/bhp-hr or less.
Sud-Chemie Inc EnviCat-DPF	DPF	85%	N/A	Stationary prime and emergency standby generators and pumps; 15 ppm sulfur diesel.

Table VIII-4 - Verified Level 2 DECS (as of April 6, 2007)

Product Name	Technology Type	PM Reduction	NOx Reduction	Applicability
Donaldson	Flow Through Filter	50%	N/A	1991-2002 on-road; 15 ppm sulfur diesel.
Lubrizol PuriNOx	Emulsified Fuel	50%	15%	1988-2003 on-road.
Engine Control System AZ Purimuffler/Purifier	DOC + Alt Fuel	50%	20%	1996-2002 off-road; PuriNOx
Rypos ADPF	DPF	50%	N/A	1996-2002 stationary engines; CARB diesel.

Table VIII-5 - Verified Level 1 DECS (as of April 6, 2007)

Product Name	Technology Type	PM Reduction	NOx Reduction	Applicability
Donaldson DCM 6000	DOC	25 %	N/A	1988-1990 on-road; 15 ppm sulfur diesel; CARB diesel.
Donaldson 6000 + Spiracle	DOC + crankcase filter	25 %	N/A	1988-2002 on-road; 15 ppm sulfur diesel; CARB diesel.
Donaldson DCM 6100 + Spiracle	DOC + crankcase filter	25 %	N/A	1991-2002; CARB diesel.
Donaldson DCM 6100	DOC	25 %	N/A	1994-2002; 15 ppm sulfur diesel.
Donaldson 6000 + Spiracle (off-road)	DOC + crankcase filter	25 %	N/A	Off-road port equipment; 15 ppm sulfur diesel; CARB diesel.
Extengine	DOC + SCR	25 %	80 %	1991-1995 Cummins 5.9 liter off-road; 15 ppm sulfur diesel or CARB diesel.
Engine Control System AZ Purifier & Purifmuffler	DOC	25 %	N/A	1991-2003 Cummins and Navistar on-road; 15 ppm sulfur diesel. 1973-1993 DDC 2 stroke; CARB diesel.1991-2002 HHD certain model Cummins and DDC; 15 ppm sulfur.
Engine Control System AZ Purifier & Purifmuffler	DOC	25 %	N/A	1996-2002 off-road; 15 ppm sulfur diesel.
Paceco Corporation	DPF	25 %	N/A	Pre-1996 model year or Tier 1, 2, or 3 certified off-road diesel engines on rubber-tired gantry cranes.

In order to determine if a particular DECS will work with a specific engine and vehicle combination, the conditions contained in the Executive Order (EO) or Verification Letter must be followed. The EO or Verification Letter lists the engines by engine family and other conditions of verification, such as minimum engine exhaust temperature.

Additional evaluations may then be needed, such as use of a datalogger that records engine exhaust temperatures over a typical duty cycle.

This list is subject to change as additional systems are verified. The most current list of verified DECS, applicable engine families, as well as the EO and verification letters may be found on our web site at http://www.arb.ca.gov/diesel/verdev/verdev.htm

E. Summary of Off-road Rules Requiring Retrofits

Around the world over the past several decades, various government agencies have begun to require the retrofit of in-use diesel engines, especially to reduce diesel PM. In the past 20 years, over 250,000 DOCs have been installed on underground mining and materials handling equipment, and over 750,000 DOCs have been installed on on-road and off-road vehicles worldwide. The use of DPFs is not as widespread as DOCs in part because of the requirement for very low fuel sulfur content for effective operation of a DPF. Nevertheless, Manufactures of Emission Controls Association estimated that over 200,000 DPFs have been retrofitted on heavy-duty vehicles worldwide (MECA, 2006a).

Table VIII-6 summarizes various laws, regulations, and rules that require retrofits of off-road diesel vehicles. The rules are organized by geographical location; the name of the rule is given as well as the agency responsible for the rule. A timeframe is given for the effective date of each rule. A brief description and website is given for each entry.

The Europeans have taken the lead in requiring retrofits of construction equipment. European interest in diesel retrofits was spurred in the early 1990s when large-scale tunnel projects in Switzerland, Austria, and Germany using heavy diesel equipment were planned.

The German Ministry of Labor (Bundesministerium für Arbeit - BMA) established exposure limits to toxics through TRGS (technische Regeln für Gefahrstoffe) regulations. Specific rules pertaining to the use of diesel engines in occupational health environments were first introduced in 1993 (TRGS 554). These regulations introduced a general exposure limit for diesel particulates for underground non-coal mines and tunneling. Since 1996, the TRGS 554 has required that whenever diesel engines are operated in buildings, underground, or other enclosed areas, the diesel engines must be equipped with particulate traps, provided such traps are technically feasible.

In Switzerland, the SUVA now mandates DPFs on underground diesel equipment. These retrofit requirements were phased-in between March 2000 and January 2002. Beginning in 2002, the DPF requirement was extended to general construction engines. A BUWAL directive requires that diesel engines operated within large construction sites must be fitted with particulate filters.

Various other European authorities have subsequently begun to require diesel retrofits on construction and other off-road vehicles, and German and Swiss legislation has stimulated thousands of retrofits to date. Information about worldwide diesel emission standards and regulations may be found at http://www.dieselnet.com/standards.

In the U.S., various jurisdictions in New York, New Jersey, Connecticut, Massachusetts, and California are requiring some level of retrofits on construction equipment.

New York City's Local Law 77, signed into law December 22, 2003, requires "that any diesel-powered nonroad vehicle, fifty horsepower and greater, that is owned by, operated by or on behalf of, or leased by a City agency be powered by ultra low sulfur diesel fuel and utilize the best available technology for reducing the emission of pollutants. Additionally, this legislation requires that any solicitation for a public works contract and any contract entered into as a result of such solicitation include specifications that all contractors in the performance of such contract use ultra low sulfur diesel fuel and the best available technology for reducing the emission of pollutants for diesel-powered nonroad vehicles."

New Jersey is developing a rule requiring retrofits on construction equipment and detailed Compliance Plans developed by vehicle owners. Publicly owned heavy-duty on-road and non-road vehicles, such as construction vehicles, will be required to complete and submit a Compliance Plan within 24 months of adoption of rules by New Jersey Department of Environmental Protection, or by approximately July, 2009. The rule also has a three minute idling limit.

Connecticut, Massachusetts, and New York are using contract specifications to encourage cleaner air around local construction sites by requiring emission control technologies during construction.

In California, the Los Angeles International Airport has entered into an agreement with the surrounding communities to, among other issues, restrict diesel emissions by requiring exhaust retrofits on construction equipment working on the airport. Information regarding this project is available in section F below.

In California, at least two air districts have used their authority through the California Environmental Quality Act (CEQA) to require retrofits of off-road diesel vehicles on large construction projects within their jurisdictions. The San Luis Obispo Air Pollution Control District has recommended various retrofits on construction equipment as part of CEQA mitigation measures for construction projects. The Sacramento Metropolitan Air Quality Management District (SMAQMD) requires that construction projects that exceed certain emission thresholds reduce the NOx and PM emission rates of the fleet used at the construction site.

Table VIII-6 - Rules Requiring Retrofit of In-Use Off-road Diesel Vehicles

International	
Location: Germany Name: TRG 554 Agency: BMA Year: 1996	German legislation passed in 1993 and updated in 1996, TRG 554 requires DPFs on diesel engines used underground and in closed rooms. It was estimated that by year 2000 there were 3,000-5,000 traps on construction equipment and at least 15,000 on forklifts (SAEFL, 2000). Both the German and Swiss legislation reference the VERT list. There is an English version of the approved VERT list (SAEFL, 2003), and a German version of the approved VERT list (BAFU, 2006).
Location: Switzerland Name: Ordinance on Air Pollution Control Agency: BUWAL/SUVA Year: 2000 -	Since 2000, DPF retrofits required for all diesel engines used in underground work. Since 2002, DPF retrofits required in diesel-powered construction equipment > 50 hp (2005 for > 25 hp) used at large or urban worksites. By mid-2003, there were over 6,500 pieces of construction equipment retrofitted; at that time, it was expected that by 2006 there would be 15,000 pieces of construction and underground equipment would be retrofit, although statistics have not confirmed that number (SAE, 2004; SAEFL, 2000; SAEFL, 2004).

Northeast United States	
Location: New York, NY Name: NYC Local Law #77 Agency: New York City Year: 2003 -	This legislation requires construction equipment >50 hp operating on projects funded by New York City be powered by ultra low sulfur fuel and utilize best available technology (retrofit) (NYC DDC, 2004)
Location: New Jersey Name: New Jersey Diesel Law Agency: NJ Department of Environmental Protection Time: 2005	Retrofits with tailpipe pollution controls will be required on certain types of diesel vehicles and detailed Compliance Plans will be developed by vehicle owners. Publicly owned heavy-duty on-road and non-road vehicles, such as construction vehicles, will be required to complete and submit a Compliance Plan within 24 months of adoption of rules by NJDEP, or by approximately July, 2009. Three minute idling limit (NJ, 2005).
Location: Conn., Mass., and NY Name: Contract Requirements Agency: Department of Transportation Time: Contract requirements	To encourage cleaner air around local construction sites, many agencies, organizations, businesses and institutions have initiated construction retrofit programs and are using contract specifications to call for emission control technologies (NEDC, 2007).
Western United States	
Location: Los Angeles, CA Name: LAX Master Plan Program Agency: Los Angeles World Airports Time: 2006	The LAX Community Benefits Agreement of the LAX Master Plan Program requires all diesel construction equipment be retrofitted with BACT (LAANE, 2004).
Location: San Luis Obispo, CA Name: District CEQA Review Agency: SLO Air Pollution Control District	San Luis Obispo APCD has recommended various retrofits on construction equipment as CEQA mitigation measures for projects (SLO APCD, 2004).

Location: Sacramento, CA Name: District CEQA Review Agency: Sacramento Air Quality Management District	For construction projects that exceed 85 lb/day NOx threshold, the District requires construction fleets to demonstrate NOx and PM reductions. The fleet of construction equipment used at a project must be 20 percent cleaner for NOx and 45 percent cleaner for PM than the current statewide average for off-rd construction equipment (SMAQMD, 2007).

F. Summary of Off-road Installations of PM Retrofits

As summarized previously in Table VIII-6, approximately 35,000 DPFs have been installed on all varieties of construction equipment used on large construction projects in Switzerland and in confined spaces in Germany as a result of the laws and rules adopted by those countries. As described earlier, the VERT project was the basis for subsequent retrofit mandates in these countries. As shown in Table VIII-8, in the mid-1990s, the VERT project tested 32 different DPFs on 10 pieces of construction equipment. Based on this experience, they were able to ascertain relevant criteria to measure the performance of DPFs. The Diesel Particulate Filter Manufacturers Task Force (AKPF) in Europe has compiled a database of diesel particulate filter retrofits of construction machines in Europe[22]. While the database does not provide data on every retrofit installed, it does provide data on nearly 1,700 retrofits and gives a flavor for the breadth of machine and engine types successfully retrofit.

The European experience is slowly being duplicated in the U.S. through a variety of projects. To date, the largest construction retrofit projects have been on the east coast. In Boston, on the Central Artery/tunnel Project and in New Haven, on the Interstate-95 New Haven Harbor Crossing Corridor, 200-300 pieces of construction equipment have been retrofitted with DOCs. DOCs will also be retrofitted on approximately 290 pieces of construction equipment in Chicago on the Dan Ryan Expressway.

Whereas the European retrofits have utilized DPFs almost exclusively, the retrofit projects in the U.S. have, to date, mostly utilized DOCs. The U.S. retrofit projects using DPFs include 8 vehicles in a City of Houston study, 12 pieces of construction equipment in the South Coast Air Quality Management District (SCAQMD) / Construction Industry Air Quality Coalition (CIAQC) study, and 5 pieces of construction equipment in a SMAQMD study. Additionally, the Croton Project (a North Bronx drinking water treatment plant construction project) retrofitted over 25 pieces of construction equipment with both actively and passively regenerating DPFs.

A project in California utilizing DPFs on construction vehicles is currently underway at the runway relocation construction project at the Los Angeles International Airport (LAX). This project began in mid-2006. Listed in

[22] AKPF database can be found in Appendix G

Table VIII-7 are the twelve off-road construction vehicles utilized on this project that have been retrofitted with exhaust DPFs, and the hours accumulated on the vehicles with the retrofits as of February 2007.

Table VIII-7 - Off-Road Vehicles with DPFs at LAX Runway Relocation Project

Vehicle Type	Vehicle Make, Model (Engine is Same Make)	Model Year	Power Rating (HP)	Accumulated Engine Hours with DPF (February 2007)
Articulated Dump	Volvo A40	1997	398	1425
Articulated Dump	Volvo A40	1998	398	1391
Articulated Dump	Volvo A40	1998	398	1473
Articulated Dump	Volvo A40	1999	398	1382
Articulated Dump	Volvo A40	1999	398	1117
rticulated Dump	Volvo A40	2000	398	1507
Rubber Tire Loader	Caterpillar 966F Series II	1997	220	957
Rubber Tire Loader	Caterpillar 966F Series II	1997	220	857
Scraper	Caterpillar 613C	1996	175	426
Excavator	Caterpillar 330BL	1998	222	890
Excavator	Caterpillar 345BL	1998	286	1059
Compactor	Caterpillar 815F	2004	254	268

Photos of a few of these vehicles in operation at the LAX are shown below in Figure VIII-5, with the DPFs are circled in the photos.

Figure VIII-5 - Photos of DPF Installations on LAX Construction Vehicles

Caterpillar 330BL excavator. This vehicle is shown operating a hydraulic hammer. Both tracked excavators are operated part of the time with a hydraulic hammer.

Caterpillar 815F Compactor

Volvo A40 Articulated Dump Truck

Caterpillar 966F Series II Loader

Table VIII-8 shows construction and other off-road vehicle and equipment retrofit projects completed or underway. The projects are organized by geographical location, the sponsor of the project, and project timeframe. A description of each project is given.

Even with the significant number of construction retrofits that have occurred, ARB staff recognizes the need for more ARB verified diesel emission control devices for off-road applications. Therefore, the ARB is working with the Mobile Source Air Pollution Reduction Review Committee (MSRC) of SCAQMD to develop and implement an off-road construction “Showcase Program”. The Showcase Program is designed to encourage owner/operators of off-road diesel construction equipment to participate with diesel emission control system manufacturers in retrofitting their engines with diesel emission control devices. The goal of this program is to demonstrate new emission control systems that will earn ARB verified status as well as achieve significant near term emission reductions from off-road construction equipment.

Participation in the Showcase Program is open to most owners of off-road diesel construction equipment in the SCAQMD, including private construction companies, public agencies, and local governments. The MSRC will provide $1,000,000 in incentives that will pay for the cost and installation of the retrofit devices. The MSRC released program announcements for the Showcase Program on March 2, 2007 which can be found at:
http://www.cleantransportationfunding.org.

Table VIII-8 - Projects Involving Retrofit of In-Use Off-road Diesel Vehicles

LOCATION	NAME	AGENCY	TIME FRAME	DESCRIPTON / WEBSITE
International				
EU	VERT	German, Austrian, Swiss authorities	1994-2000	10 pieces of construction equipment were variously retrofitted with 1 DOC and 32 different DPFs and tested (Mayer, 1998; VERT, 2000).
Canada	Stobie Mine Demonstration	Diesel Emissions Evaluation Program (DEEP) INCO	2000-2004	5 scooptrams and 4 tractors were retrofit with DPFs and tested in the Stobie Mine (DEEP, 2006).
NorthEast United States				
Boston, MA	Central Artery/Tunnel (CA/T) Project, aka, “Big Dig”	Massachusetts Turnpike Authority (MTA)	1992 – 2005 (retrofitting started in 1998)	100 – 200 non-road pieces of equipment including excavators, front-end loaders, dump trucks, cranes, lifts, and bulldozers retrofitted with DOCs and/or PuriNOx (AWMA, 2002; MTA, 2005).
Massach-usetts	Impact of Retrofit Exhaust Control Technologies on emission From Heavy-Duty Construction Equipment	NESCAUM, Environment Canada, Manufacturers of Emission Control Association	1999	Test program of 5 pieces of construction equipment, 3 with DOC and 2 with DPFs (MECA, 2006b).

New Haven, CT	I-95 New Haven Harbor Crossing Corridor	Connecticut Department of Transportation (CONNDOT)	2002 – 2013	84 to date and ~200 by project end pieces of construction equipment retrofitted with DOCs and PuriNOx. To date, all contractors have elected to install DOCs. Retrofit requirements apply to all equipment of 60 hp or more assigned to construction for 30 days or more. Contractors required to submit initial and monthly reports to CONNDOT (I95, 2002a; I95, 2002b).
New York City, NY	World Trade Center	Clean Air Communities (CAC) Port of Authority of New York and New Jersey	2001 -	Retrofit 8 pieces of construction equipment and 10 pieces of construction equipment will use ultra-low sulfur diesel fuel (CAC, 2003). Also, two wheel loaders were retrofit with DPFs and tested (Bradley, 2004).
New York City, NY	Croton Water Treatment Plant	New York Department of Environmental Protection (NYDEP)	2005 - 2012	25 – 30 pieces of construction equipment with both active and passive DPFs (Croton, 2007).
MidWest / South United States				
Chicago, IL	Dan Ryan Expressway	Illinois Environmental Protection Agency (IEPA) and Illinois Department of Transportation (IDOT)	- 2007	About 290 pieces of construction equipment will be retrofit with DOCs and ultra-low sulfur diesel fuel. Illinois Tollway Authority has adopted this projects retrofit requirements for three other tollway construction projects (IDOT, 2005).
Atlanta, Georgia	Hartsfield International Airport		2001	Construction equipment will be retrofit (Diesel Forum, 2003).

Houston, TX	Port of Houston Pilot Retrofit Program	Port of Houston Authority	2004	50-250 equipment/vehicles to be retrofit including yard hustlers, cranes, and rubber tired gantries (Diesel Forum, 2003).
Houston, TX	City of Houston Field Demonstration	City of Houston,	2000-2001	29 pieces of equipment and vehicles, both on and off-road, were retrofitted with various diesel emissions control devices, 26 of which were subjected to emissions testing (EC, 2001)
Western United States				
Los Angeles, CA	SCAQMD / CIAQC Retrofit Demonstration	South Coast Air Quality Management District	2001 - 2003	12 scrapers and dozers were retrofitted with DPFs (SCAQMD, 2005).
Sacramento, CA	SMAQMD Construction Equipment Retrofit Demonstration	Sacramento Metropolitan Air Quality Management District and the West Coast Collaborative	2006-	SMAQMD will retrofit 5 pieces of construction equipment The project will evaluate and report on the success of the retrofit technology and the amount of reductions of particulate matter and other air pollution emissions (WCC, 2006)

Additional information can be found at:

http://epa.gov/cleandiesel/documents/retrofit-tech-prog-exp.07-2005.pdf#search=%22SAe%201999-01-0110%22

http://www.epa.gov/cleandiesel/construction/casestudies.htm

http://www.meca.org/page.ww?section=Useful+Documents&name=Useful+Documents

http://www.environmentaldefense.org/cleanairforlife.cfm?subnav=handbook

http://www.dieselnet.com/

G. Repowers

Strategies to meet the regulation requirements may include replacing an older engine with a cleaner, new engine through either repowering, or replacement with a newer vehicle. Repowering is defined as replacing an older engine with a newer engine into the same vehicle that is certified to a lower emission standard.

Upgrading to a newer engine can provide significant emission reductions when the new engine is a higher tier level (i.e., replacing a pre-Tier 1 engine with a Tier 2 engine). Employing a newer engine achieves reductions of all exhaust constituents (including PM and NOx), as opposed to retrofitting with a PM-only exhaust aftertreatment device. Repowering to a Tier 2 or 3 engine and then adding a retrofit further reduces emissions. However, repowering is not an option for all vehicle types and configurations.

While the cost to repower an off-road vehicle's engine is roughly three to four times the cost to rebuild an existing engine, the benefits may justify the expense. The engine may operate more smoothly, have more power and improved torque characteristics, require reduced maintenance, and the emissions will be reduced. A newer engine will be more suitable to aftertreatment emission controls to further reduce emissions, which would assist in meeting the requirements of this regulation.

Repowering is often an attractive strategy for owners of vehicles whose engines have reached their useful life before the other vehicle components are ready for retirement. Repowering is most cost-effective when newer or new machine replacement costs are much higher than the costs of repowering.

The repower of hundreds of off-road mobile equipment, and thousands of other types of equipment such as trucks, buses, and agricultural pumps, has been achieved through grant programs such as the Carl Moyer grant program, which is overseen by the ARB and managed by the local air districts. Through the Carl Moyer grant program, over 4,500 on- and off-road diesel-powered vehicles and equipment have been repowered (ARB, 2007). This number includes more than 300 off-road vehicles such as scrapers, wheel loaders, compactors, tractors, excavators, and rough terrain forklifts. The new engines funded through the Carl Moyer grant program have been Tier 1, 2, and 3, with approximately one-third being Tier 3 engines. The sizes of the engines repowered in the Carl Moyer program range from less than 100 horsepower to over 600 horsepower. In almost all cases, the repower engine is from the same manufacturer as the original engine, although a few are from a different manufacturer. The most popular vehicles repowered through the Carl Moyer program have been Caterpillar scrapers, of which there have been over 130 repowered, with many having both engines repowered.

For certain off-road equipment, repowering from a pre-controlled engine to a Tier 1 certified engine is relatively straightforward. The engine block has the same dimensions, and external to the engine, the major changes required are usually limited to exhaust lines. While repowering from a pre-controlled engine to a Tier 1 engine is the least complex and lowest cost, the emission benefits are smaller than repowering to a newer, lower tier engine.

Higher tier Off-road diesel engines have undergone major design changes to meet new and more stringent emission regulations. Off-road engine manufacturers have made significant hardware modifications in order to meet the Tier 2 and Tier 3 (Tier 2/3) emission standards. The incorporation of larger radiators, air-to-air aftercoolers and other auxiliary systems have resulted in Tier 2/3 engine packages that are physically different than Tier 1, which necessitates more room inside the engine compartment. Repowering to a Tier 2/3 engine has increased complexity and often requires fan, radiator, air-to-air aftercooler, associated piping, and other components in the engine compartment to be changed out or added, and some parts such as brackets and supports may need to be fabricated. For some vehicles, accommodating the larger engine package may require the frame of the vehicle to be cut and extended. This complexity raises the cost of repowering. In addition, some larger Tier 0 and Tier 1 engines are a “V” configuration block, while newer engines are nearly all inline configurations. The inline engines are longer and taller. Therefore, to repower from a “V” engine, the frame of the vehicle may need to be cut and extended, and the engine cover raised to accommodate the longer and taller engine and associated components.

Most off-road vehicles mount equipment to the front of the vehicle or have equipment that operates in the front of the vehicle (blade, scoop). Vehicles such as scrapers and motor graders have equipment mounted in the middle of the vehicle. Therefore, these types of vehicles are amenable to frame extensions to accommodate a longer engine, both for the front engine and the rear engine (if applicable). These types of vehicles often have space inside the engine compartment, and are also larger and more expensive to purchase, making them more likely candidates for cost-effective repowering.

Tier 4 engines are expected to utilize all new engine designs and components, and will require exhaust aftertreatment devices and control systems as part of their engine design. It will likely be challenging to repower off-road vehicles with Tier 4 engines. Therefore, while it is technically and cost-effectively feasible for many off-road vehicles to be repowered, not all off-road vehicles can accept Tier 2/3 engines packages due to space constraints and other considerations, and repowers with Tier 4 engines will be even more challenging, if at all possible.

H. Replacement of Off-Road Vehicles

In the case of older off-road vehicles, in particular those with a low resale value, accelerating the turnover to new or newer on-road vehicles is a cost-effective approach to achieve significant reductions in both diesel PM and oxides of nitrogen (NOx) while maintaining economic feasibility (cost-effectiveness). When replacing an older off-road vehicle with one that is new or newer, emissions will be reduced. A newer engine can also make the vehicle more suitable to aftertreatment emission controls to further reduce emissions, which would assist in meeting the requirements of this regulation. Also, a newer vehicle offers other benefits such as lower maintenance costs, increased power, improved functionality, improved operator ease of use and comfort, and longer life. The cost difference between newer used equipment and brand-new is usually significant, making purchasing relatively new but used vehicles a potentially attractive compliance option for off-road equipment.

I. Availability

As a result of this regulation there will be a need for an increased number diesel PM exhaust aftertreatment retrofit devices manufactured, and used and new vehicles available for purchase. Staff examined the current and future supply and demand due to typical business practices and air quality regulations and determined there will be sufficient manufacturer capacity to meet this increased demand due to this regulation.

1. Diesel Exhaust Retrofits

New engine standards for both on- and off-road engines over the next 3-7 years will require the installation of DPFs by the engine manufacturers. There are approximately 350,000 new on-road medium- and heavy-duty diesel vehicles purchased nationally each year. In addition, over 329,500 new off-road construction vehicles are purchased nationally each year (Census, 2006). For some horsepower groups, the Tier 4 Interim standards for off-road engines begin in 2011, and to meet these stringent standards the engines will be equipped with PM exhaust aftertreatment devices. Between the two requirements, nearly 680,000 new engines each year will be retrofitted with DPFs. Staff estimates that at most the regulation would require 35,000 exhaust aftertreatment retrofit devices to be installed on vehicles in any one year. This value is considerably less than the nearly 680,000 which will be required annually on new on- and off-road engines. Staff is confident that sufficient manufacturing capacity will be available to produce the demand for diesel PM exhaust aftertreatment retrofit devices that results from this regulation. This estimate for the number of diesel PM exhaust aftertreatment retrofit devices that will be installed is from modeling work performed in support of this regulation.

2. Used Vehicles

The turnover requirements imposed by the regulation will require a maximum of 10 percent (eight percent in the initial years) of the statewide fleet's horsepower to turn over per year. The baseline natural rate of turnover of the statewide fleet is about 5 percent per year. Thus, the regulation will at most require 5 percent more turnover per year than normal. The regulation affects about 180,000 vehicles, so the maximum annual increase in demand for Tier 2 or better vehicles and engines in California will be an additional 5 percent, or about 9,000 per year. Staff believes this demand is likely to be satisfied through engine repowers, purchase of new vehicles, purchase of used vehicles, and/or installation of NOx retrofits.

Staff compared the number of used off-road vehicles recently for sale on two used equipment websites on a single day. On these two sites, there were over 80,000 vehicles for sale and over 30,000 of them were 2003 model year or newer (likely Tier 2 or better) (Ritchie Brothers, 2007; Machinery Trader, 2007). By the time the first requirements for accelerated turnover take effect in 2010, there is likely to be an even greater number of Tier 2 or better used vehicles available. Based on this evaluation, it appears likely that there will be a sufficient number of used vehicles available to meet the increased demand due to the regulation.

3. New Vehicles

Staff also believes enough new vehicles will be available to satisfy the requirements of the regulation. As stated above, the regulation will increase demand for vehicles by at most about 9,000 vehicles per year. This demand in the context of the national and international market for off-road diesel vehicles is small. In 2005, there were over 329,000 new off-road vehicles sold in the United States. If all fleets were to comply with the regulation by buying new vehicles then the increase in demand would represent less than 3 percent of national sales.

Further, the regulation contains provisions so that fleets are not penalized if manufacturer delays prevent them from acquiring the equipment or vehicles they need to comply. Also, the proposed regulation contains special provisions that exempt specialty equipment for which repowers and cleaner used vehicle replacements are not available from the mandatory turnover requirements. So, for example, if there were a shortage of a certain type of scraper such that new scrapers could not be obtained, scraper owners would not be penalized for that shortage.

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IX. ENVIRONMENTAL IMPACT

This chapter discusses the potential impacts that the proposed regulation may have on public health and the environment, including air, water or soil. Based on the analysis performed, staff expects significant environmental benefits and does not anticipate any significant adverse public health or environmental impacts associated with the proposed regulation.

The proposed regulation will accelerate the introduction of newer cleaner engines and retrofits for PM emissions controls on existing engines in the statewide fleet, providing significant emission benefits. However, these cleaner engines and retrofit devices can have a fuel economy penalty that can cause increased emissions of CO_2 – a greenhouse gas and global warming contributor. Provisions in the rule that could offset the potential global warming increase associated with fuel penalty effects include: the reduction of black carbon emissions, limits on unnecessary idling which reduces CO_2 emissions, and credit to fleets for replacing diesel vehicles with electric and alternative fuel vehicles.

A. Legal Requirements

The California Environmental Quality Act (CEQA) and ARB policy require an analysis to determine the potential environmental impacts of proposed regulations. Because the ARB's program involving the adoption of regulations has been approved by the Secretary of Resources pursuant to Public Resources Code, section 21080.5, the CEQA environmental analysis requirements may be included in the Initial Statement of Reasons (ISOR or Staff Report) for this rulemaking in lieu of following the CEQA format of an Initial Study and an Environmental Impact Report or Negative Declaration. In addition, ARB staff will respond, in the Final Statement of Reasons for the regulation, to all significant environmental issues raised by the public during the public review period or at the Board public hearing.

Public Resources Code section 21159 requires that the ARB's environmental impact analysis include the following:

- An analysis of the reasonably foreseeable environmental impacts of the methods of compliance;
- An analysis of reasonably foreseeable mitigation measures; and
- An analysis of reasonably foreseeable alternative means of compliance with the regulation.

Compliance with the proposed regulation is expected to directly affect air quality and potentially affect other environmental media. Our analysis of the reasonable foreseeable environmental impacts of the methods of compliance is presented in Section IX.B below. Regarding mitigation measures, CEQA requires the lead agency to identify and adopt feasible mitigation measures that would minimize any significant adverse environmental impacts described in the environmental analysis.

The proposed regulation is designed to reduce emissions of diesel PM – a toxic air contaminant – and NOx. The diesel PM reductions are needed to reduce the public health impacts from exposure to diesel PM as required by Health and Safety Code (HSC) sections 39666 and 39667, and to fulfill the goals of the October 2000 Diesel Risk Reduction Plan (ARB, 2000). The NOx emissions reductions are needed to provide the ozone and particulate matter precursor emissions reductions required to achieve attainment in those areas of the State that violate the National and State ambient air quality standards for ozone and particulate matter. The regulation is also necessary to fulfill ARB's obligations under HSC 43013 and 43018 to achieve the maximum feasible and cost effective emission reductions from all mobile source categories, including off-road diesel engines and equipment.

Alternatives to the proposed regulation are discussed in Chapter 10 of this report. ARB staff has concluded that there are no alternative means of compliance that would achieve similar diesel PM emission reductions at a lower cost.

B. Reasonably Foreseeable Environmental Impacts

Staff has identified both benefits and potentially adverse environmental impacts of compliance with the proposed regulation.

1. Statewide Air Quality Impacts

Off-road engines are major contributors to particulate matter and ozone pollution. The proposed regulation will provide diesel PM and NOx emissions reductions that will have a substantial positive air quality impact throughout California. By reducing ambient levels of particulate matter and ozone, the regulation will help with the progress towards attainment of National and State ambient air quality standards for PM and ozone. Significant additional health benefits will also be obtained with the reductions of ambient levels diesel of PM, a TAC.

The emissions benefits of the regulation are summarized in Table IX-1 below and discussed in more detail later in this chapter. Staff estimates that between 2010 and 2030, as older engines are replaced with newer engines or retrofitted with diesel exhaust control systems, PM emissions will be reduced by an average of 1,560 tons per year and NOx by an average of 8,900 tons per year. During the same time period, there will be a reduction of approximately 1,600 tons per year of ROG and 9,300 tons per year of CO.

The PM, NOx and ROG emissions reductions from the proposed regulation and the resulting reduction in ambient levels of these compounds will help with efforts to achieve ambient air quality standards for both PM2.5 and ozone in non-attainment areas of the State.

Table IX-1 - Emission Benefits from Implementation of the Proposed Regulation

Benefits of Regulation (2010 – 2030)	PM	NOx	ROG	CO
Emissions Removed (total tons)	33,000	187,000	34,000	195,000
Annual Average Reductions (tons per year)	1,560	8,900	1,600	9,300

a) Methodology

The projected emissions reductions were determined by comparing the baseline inventories and controlled inventories. The baseline inventories represent current and future emissions accounting for the emissions benefits of the new off-road diesel engine emissions standards, but they do not include the reductions projected for the proposed regulation. Chapter 6 presents an overview of the methodology used to generate the baseline inventories while Appendix E provides a more detailed description. The controlled inventory represents future emissions based on the proposed regulation. The methodology used to develop the controlled inventories is based on individual fleet analyses which are discussed in Chapter 11. The emissions reductions were determined by analyzing many fleets and then scaling the reductions to represent statewide fleet reductions.

b) Reduction of PM and NOx Emissions

The projected PM emissions reductions from implementation of the proposed regulation are presented in Table IX-2 and Figure IX-1, while the NOx emissions reductions are shown in Table IX-3 and Figure IX-2.

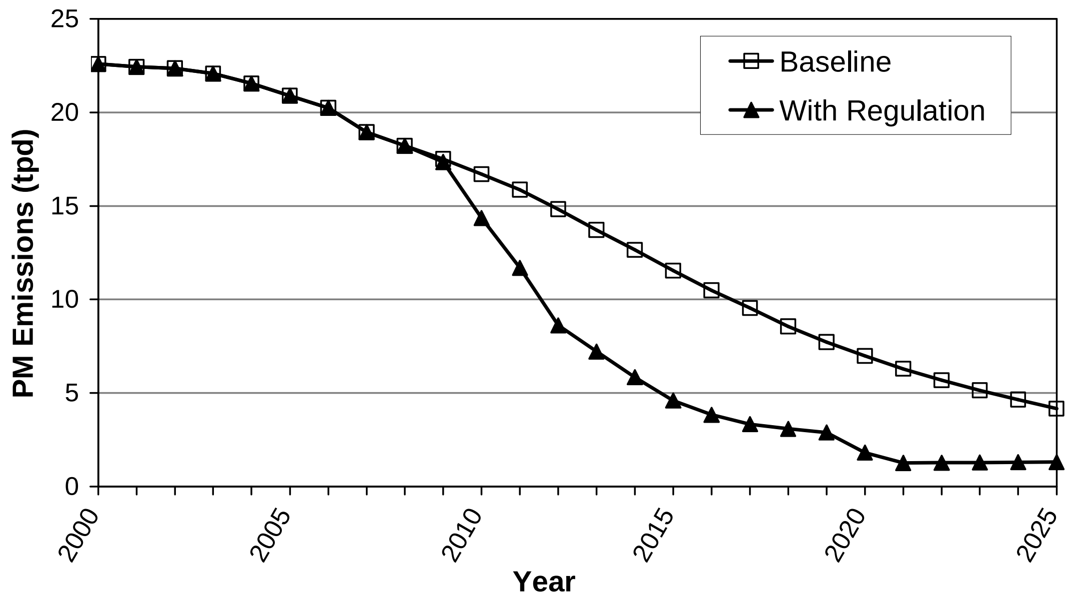
As the baseline inventory estimates show, a decline in overall PM and NOx emissions from off-road diesel engines is expected in the near term as the off-road fleet becomes increasingly dominated over time by engines that comply with existing emission regulations. However, these reductions are not sufficient to meet ambient air quality standards. Without additional emissions reductions from these engines, this downward trend in emissions is expected to reverse and emissions are expected to rise in the future as the effect of growth in the population of the off-road sector surpasses the effect of the existing standards.

Staff estimates that with implementation of the proposed regulation, diesel PM emissions will be reduced by about 4.6 tons per day (tpd) in 2015 and 5.2 tpd in 2020 relative to baseline levels. These reductions represent a 60 percent decrease in PM emissions in 2015 and a 74 percent decrease in 2020. Also, the projected PM emission rate in 2020 (1.8 tpd) will be 92 percent lower than the 2000 baseline level of 23 tpd. Therefore, the regulation achieves the goal of the Diesel Risk Reduction Plan of reducing diesel PM by 85 percent by 2020.

Table IX-2 - Statewide PM Emissions Benefits from the Proposed Regulation

Calendar Year	PM Emissions (tons per day)		Projected Reductions	
	Baseline	With the Regulation	(tons per day)	Percent from Baseline
2010	16.7	14.4	2.3	14%
2015	11.5	4.6	6.9	60%
2020	7.0	1.8	5.2	74%
2025	4.2	1.3	2.9	69%

Figure IX-1 Projected PM Emissions With and Without the Regulation

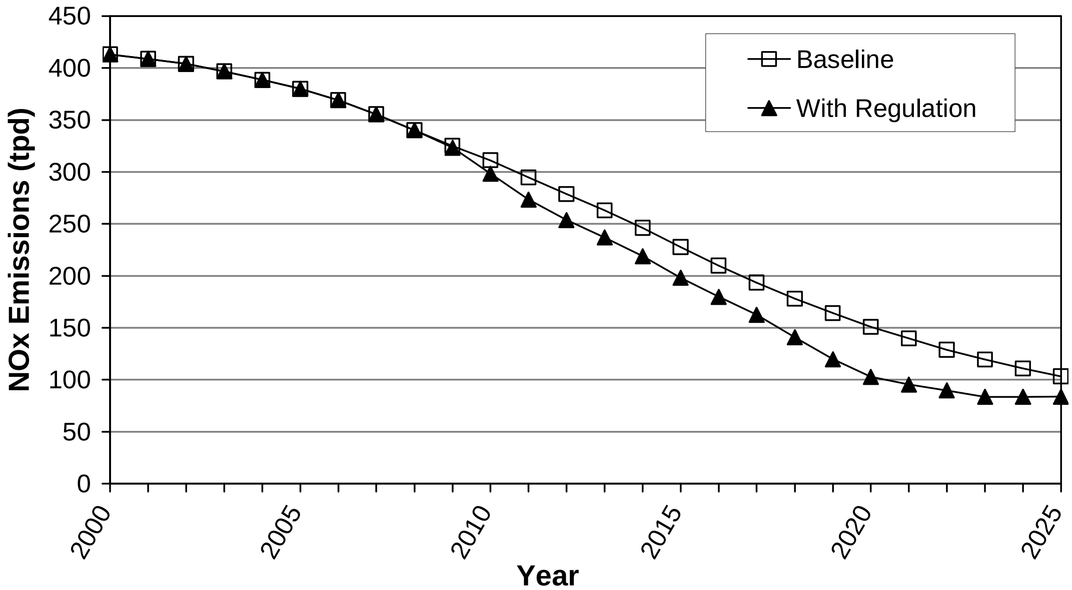


The projected NOx emissions reductions from the proposed regulation are 30 tpd and 48 tpd, for 2015 and 2020, respectively. NOx emissions would be 13 percent lower in 2015 and 32 percent lower in 2020 than they would be in the absence of the proposed regulation.

Table IX-3 - Statewide NOx Emissions Reductions from the Proposed Regulation

Calendar Year	NOx Emissions (tons per day)		Projected Reductions	
	Baseline	With the Regulation	(tons per day)	Percent from Baseline
2010	311	298	13	4 %
2015	228	198	30	13 %
2020	151	103	48	32 %
2025	103	84	20	19 %

Figure IX-2 Projected NOx Emissions With and Without the Regulation



c) Reduction of Emissions of Other Pollutants

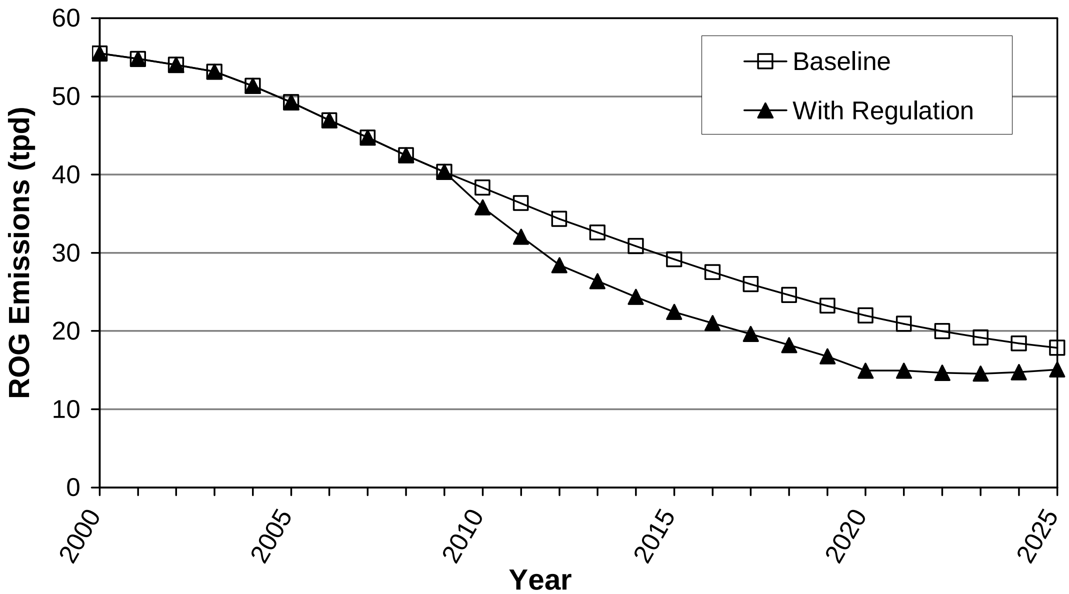
A diesel particulate filter can effectively catalyze the oxidation of hydrocarbons (HC) to CO_2 and H_2O. Toxic hydrocarbon emissions are typically reduced in proportion to total hydrocarbon emissions (U.S. EPA 2004a). Staff estimates assumed that about 30 percent of the vehicles with PM exhaust retrofits would have passive systems with catalyzed DPFs. For these vehicles ROG was assumed to decrease by 85 percent.

The projected ROG emissions reductions from the proposed regulation are 6.7 tpd and 7.0 tpd, for 2015 and 2020, respectively. These reductions represent a 23 percent decrease in PM emissions in 2015 and a 32 percent decrease in 2020 compared to the respective baseline emissions.

Table IX-4 - Statewide ROG Emissions Reductions from the Proposed Regulation

Calendar Year	ROG Emissions (tons per day)		Projected Reductions	
	Baseline	With the Regulation	(tons per day)	Percent from Baseline
2010	38	36	2.5	7 %
2015	29	22	6.7	23 %
2020	22	15	7.0	32 %
2025	18	15	2.8	15 %

Figure IX-3 - Projected ROG Emissions With and Without the Regulation



2. Impact on the State Implementation Plan

The proposed regulation is one of the new measures in the draft SIP currently being developed by ARB staff. Both the South Coast and San Joaquin Valley must achieve significant NOx reductions to meet the ambient PM2.5 standard by the federally mandated 2015 deadline. U.S. EPA guidelines require that the necessary emission reductions be achieved by 2014. Significant NOx reductions are also needed by these two regions to meet their ozone attainment deadlines which are currently 2021 for the South Coast and 2013 for the San Joaquin Valley. In light of the magnitude of the NOx reductions needed, these two regions are expected to take the full time allowable, with ozone attainment deadlines as late as 2024 (ARB 2007b). The necessary emission reductions would then have to be achieved by 2023 for ozone attainment.

Table IX-5 and Table IX-6 show the PM2.5, NOx and ROG emissions reductions from the proposed regulation projected for the South Coast and San Joaquin Valley, respectively. The reductions are shown for 2014 – the current attainment deadline for PM2.5 and for 2023 – the latest attainment deadline for ozone. The reductions are based on the projected statewide emissions reductions reported earlier in section 1 of this chapter. The South Coast air basin accounted for 36 to 39 percent of the statewide baseline inventory, depending on the year and pollutant, while the corresponding range for the San Joaquin Valley, was 12 to 14 percent.

As shown in Table IX-5, the proposed regulation would reduce NOx emissions from off-road diesel vehicles in the South Coast by about 10 tons per day in 2014 and 13 tons per day in 2023. In 2014, the projected emissions would be about 11 percent lower than would occur in the absence of the regulation, and in 2023, they would be 30 percent below the 2023 baseline emissions. Although the benefits of the rule are significant, California may still come up short of achieving the needed emission reductions from this vehicle emissions category.

Table IX-5 - Projected Emissions Reductions from the Proposed Regulation in the South Coast

Calendar Year	Emissions (tons per day)					
	PM2.5		NOx		ROG	
	Baseline	Reductions	Baseline	Reductions	Baseline	Reductions
2010	6.6	0.9	117	4.8	14.9	1.0
2014	5.0	2.7	93	10.3	12.0	2.5
2020	2.8	2.1	55	17.6	8.5	2.7
2023	2.0	1.5	44	13.1	7.4	1.8

As Table IX-6 shows, the proposed regulation would reduce NOx emissions from off-road diesel vehicles in the San Joaquin Valley by about 3.6 tons per day in 2014 and 5.1 tons per day in 2023. In 2014, the projected NOx emissions would be about 11 percent lower than would occur in the absence of the regulation, and in 2023, they would be 30 percent below the 2023 baseline emissions.

Table IX-6 - Projected Emissions Reductions from the Proposed Regulation in the San Joaquin Valley

Calendar Year	Emissions (tons per day)					
	PM2.5		NOx		ROG	
	Baseline	Reductions	Baseline	Reductions	Baseline	Reductions
2010	2.0	0.3	41	1.7	4.7	0.3
2014	1.5	0.8	33	3.6	3.8	0.8
2020	0.9	0.6	22	6.9	2.9	0.9
2023	0.7	0.5	17	5.1	2.5	0.6

The regulation would also benefit all other ozone nonattainment areas in the State, including Sacramento, San Diego, Ventura, and the San Francisco Bay Area.

3. Potential Negative Impacts

Staff has identified two potential negative impacts resulting from the potential use of catalyzed diesel particulate filters to comply with the proposed regulation. They are: 1) increased NO_2 emissions resulting in increased NO_2 exposure, and 2) the need to manage the hazardous ash that accumulates on the filter.

a) Increased Nitrogen Dioxide Emissions with Passive Catalyzed Diesel Particulate Filters

While not the case with active diesel particulate filters, most catalyzed diesel particulate filters (CDPF) form nitrogen dioxide (NO_2) as part of their normal operation. The CDPF works by mechanical filtration of PM from the exhaust through a ceramic or metallic filter followed by oxidation of the captured PM – mostly elemental carbon particles – to CO_2 which is released to the atmosphere. The oxidizing agent for this process (filter regeneration) is NO_2 which is produced through the catalytic oxidation of the nitric oxide (NO) created in the engine combustion process.

Typically, more NO_2 is created than is actually used during the regeneration process, and the excess is emitted. Emissions measurements have shown an increase in the NO_2 fraction of NO_X emissions (NO plus NO_2) from heavy-duty diesel vehicles equipped with passive catalyzed diesel particulate filters even though total NO_X emissions remain approximately the same. The NO_2 to NOx ratios downstream from a CDPF could range from 20 to 70 percent, depending on factors such as the diesel particulate filter systems, the sulfur level in the diesel fuel, and the duty cycle (DaMassa, 2002). On average, for diesel engines not equipped with a CDPF, about 7 percent of the emitted NOx is in the form of NO_2 (ARB 2006).

The ARB's Verification Procedure sets limits for secondary emissions from verified emission control systems. The limit on NO_2 emissions is intended to limit increases in ambient NO_2, secondary nitrate PM, and ozone, and adverse public health impacts. The regulation allows a maximum NO_2 increase equivalent to 30 percent of the total baseline NOx. Beginning January 1, 2009, the maximum increase will be reduced to 20 percent.

It is unclear to what extent NO_2 emissions will increase as a result of the proposed regulation, since any increase is dependent on the use of CDPFs relative to uncatalyzed DPFs. Consequently, staff is unable to quantify this impact.

Higher NO_2 emissions will result in a very small increase in ambient levels of NO_2 and ozone – pollutants associated with adverse health effects including respiratory symptoms, cardio-respiratory hospital admissions, and reduced lung function (ARB 2007a). Currently, all of California is in compliance with the State 1-hour ambient NO_2 air quality standard, often by a wide margin. Staff analyzed the impact on microscale exposures such as at schools where school buses idle and on freeways with heavy diesel traffic. The analysis showed no violations of the 1-hour standard (ARB 2006). The anticipated reductions in NOx and associated ozone from the proposed regulation are expected to more than offset any increases in ozone formation from increased NO_2 emissions from CDPFs.

b) Ash Management

The particulate matter trapped by a DPF includes solid carbonaceous material or soot, semi-volatile organic matter (SOF), and inorganic solid particles. During the regeneration of the trap, the captured soot and other combustible organic matter are oxidized to carbon dioxide and water, but the inorganic material is not typically combusted and accumulates on the filter as an ash. The DPF provides an environmental benefit by filtering metallic ash from the exhaust, but for effective operation of the DPF, the accumulated ash, which is classified as a hazardous waste, must be periodically removed from the filter.

The principal source of the ash is fuel additives, engine lubricating oil, salts from environmental air, and motor wear. It primarily consists of oxides, sulfates and phosphates of iron, calcium, and zinc. Depending on the concentration of zinc, the ash may be may be classified as a hazardous waste. Title 22, CCR, section 66261.24 establishes two limits for zinc in a waste: 250 milligrams per liter for the Soluble Threshold Limit Concentration and 5,000 milligrams per kilogram for the Total Threshold Limit Concentration. The presence of zinc at or above these levels would cause a sample of ash to be characterized as a hazardous waste.

Under California law, it is the generator's responsibility to determine whether their waste is hazardous or not. Applicable hazardous waste laws are found in the HS&C, division 20; title 22, CCR, division 4.5, and title 40 of the Code of Federal Regulations. Staff recommends that owners who install a DPF on a vehicle contact both the manufacturer of the DECS and the California Department of Toxic Substances Control (DTSC) for advice on waste management.

DTSC personnel have advised ARB that it has a list of facilities that accept waste from businesses that qualify as a conditionally exempt small quantity generator. Such a business can dispose of a specific quantify of hazardous waste at certain Household Hazardous Waste events, usually for a small fee. An owner who needs specific information regarding the identification and acceptable disposal methods for this waste should contact the California DTSC.[23]

The technology exists to reclaim zinc from waste. For example, the Swedish company MEAB has developed processes for extracting zinc and cadmium from various effluents and industrial waste streams, but this reclamation for reuse has not yet been demonstrated to be economically feasible. (MEAB, 2003)

[23] Information can be obtained from local duty officers and from the website: http://www.dtsc.ca.gov.

Because of the time and costs associated with filter maintenance, there are also efforts by industry to reduce the amount of ash formed. Most of the ash is formed from the inorganic materials in engine oil, particularly from zinc-containing additives necessary to control acidification of engine oil – due in part to sulfuric acid derived from sulfur in diesel fuel. As the sulfur content of diesel fuel is decreased, the need for acid neutralizing additives in engine oil should also decrease. There are also a number of ongoing technical programs to determine the impact of changes in oil ash content and other characteristics of engine oil on exhaust emission control technologies, engine wear and performance.

It may also be possible to reduce the ash level in diesel exhaust by reducing oil consumption from diesel engines. Diesel engine manufacturers over the years have reduced engine oil consumption in order to reduce PM emissions and to reduce operating costs for engine owners. Further improvements in oil consumption may be possible in order to reduce ash accumulation rates in diesel particulate filters.

c) Impact on Transportation Emissions

The cost of the regulation for the construction industry would be less than 0.3 percent of all construction value in the state. If this cost resulted in 0.3 percent fewer lane miles of road construction each year and the delay resulted in more idling, any adverse emissions impact would be negligible compared to the emissions reductions achieved by the proposed regulation. First, the impact would not affect all vehicles operating in the state, but even if all cars and trucks operating in the state idled 0.3 percent more time each year, the increase in emissions would still be much less than 0.1 percent of the emissions benefits from the proposed regulation and less than the emissions benefits from the proposed regulation’s idling provisions alone.

4. Environmental Justice and Neighborhood Impacts

The objectives of ARB’s statewide regulatory programs are better air quality and reduced health risk for all residents throughout California. The Board has a policy that community health and environmental justice (EJ) concerns be addressed in all of ARB’s regulatory programs. Chapter 3 of this Staff Report gave an overview of ARB’s commitment to integrating environmental justice in all its activities.

With implementation of the proposed regulation, PM and NOx emissions as well as associated cancer risks and other health impacts will decrease over time as all off-road vehicle fleets become cleaner. This is consistent with the ARB’s EJ policy of reducing exposure to air pollutants and reducing the adverse impacts from TACs in all communities, including low-income and minority communities. The limit on unnecessary idling will also result in decreased emissions from engines that operate in neighborhoods.

C. Health Benefits Analysis

The emissions reductions obtained with implementation of this proposed regulation will result in lower ambient PM and ozone levels and reductions in public exposure to these pollutants. The potential health impacts of PM and NOx emissions from off-road engines and the consequent need for emissions reductions were discussed in Section IV.D.1. This section describes the health benefits of reducing emissions from these engines. It also provides the cost savings to society for each prevented premature death.

1. Reduced PM and NOx Emissions

The proposed regulation is projected to reduce diesel PM emissions by approximately 33,000 tons between 2010 and 2030. The projected NOx emissions reductions over the same time period is 187,000 tons. Reductions in these emissions would result in a reduction in the prevalence of the diseases attributed to diesel PM, reduced incidences of hospitalizations, and prevention of premature deaths.

Staff quantified the statewide cumulative impact of the total emissions removed from 2009 to 2030 through the implementation of the proposed regulation. The analysis used the same non-cancer health endpoints reported in Chapter IV.D for the impact of the 2005 baseline emissions. Appendix C provides a description of the methodology used to generate the health benefits.

The estimates reported in Table IX-7 demonstrate that the health benefits of implementing the proposed regulation are substantial. Staff estimates that the cumulative emissions reductions from 2009 to 2030 would result in approximately 4,000 fewer premature deaths, 840 fewer hospital admissions due to respiratory causes, 1,600 fewer hospital admissions due to cardiovascular causes, 110,000 fewer cases of asthma-related and other lower respiratory symptoms, 9,200 fewer cases of acute bronchitis, 680,000 fewer work loss days, and 3,900,000 fewer minor restricted activity days. Table IX-7 also shows the range for each estimated benefit.

As described in Chapter IV.D for the baseline emissions impact, the analysis of the impact of the regulation includes the benefits of reductions of direct diesel PM and indirect diesel PM – nitrates formed from precursor NOx emitted by off-road diesel engines. The impacts of direct and indirect sources of PM are listed separately in Table IX-7. The health benefits of reducing NOx as a precursor to ozone are not included in the estimates. Because only a subset of health outcomes were considered, the estimates are conservative.

Table IX-7 - Total Health Benefits Associated with Reductions in Emissions from In-Use Off-Road Diesel Vehicles

Endpoint	Pollutant	Number of Cases (Mean)	Range (95% C.I.)
Premature Mortality	NOx	610	170 - 1,000
	PM	3,400	930 - 5,800
	Total	4,000	1,100 - 6,800
Hospital admissions (Respiratory)	NOx	130	80 - 180
	PM	720	460 - 990
	Total	840	540 - 1,200
Hospital admissions (Cardiovascular)	NOx	240	150 - 370
	PM	1,300	830 - 2,000
	Total	1,600	980 - 2,400
Asthma & Lower Respiratory Symptoms	NOx.	17,000	6,800 - 28,000
	PM	94,000	36,000 - 150,000
	Total	110,000	43,000 - 180,000
Acute Bronchitis	NOx	1,400	0 - 3,000
	PM	7,800	0 - 17,000
	Total	9,200	0 - 20,000
Work Loss Days	NOx	100,000	88,000 - 120,000
	PM	580,000	490,000 - 670,000
	Total	680,000	580,000 - 790,000
Minor Restricted Activity Days	NOx	600,000	490,000 - 710,000
	PM	3,300,000	2,700,000 - 3,900,000
	Total	3,900,000	3,200,000 - 4,600,000

2. Reduced Ambient Ozone Levels

Emissions of NOx and ROG are precursors to the formation of ozone in the lower atmosphere. Off-road diesel engines contribute a substantial fraction of ozone precursors, particularly NOx, statewide. Therefore, reductions in NOx from off-road diesel engines are a considerable contribution to California's efforts to reduce exposure to ambient ozone. Controlling emissions of ozone precursors reduces the prevalence of the health effects associated with ozone exposure, such as coughing, chest tightness, inflammation and irritation of the respiratory tract, worsening of wheezing and other asthma symptoms, and reduced lung function, and would reduce hospital admissions and emergency visits for respiratory problems.

3. Health Benefit – Cost Analysis

The proposed regulation would provide significant benefits. Staff estimates the benefits to be $26 billion using a 3% discount rate or $18 billion using a 7% discount rate. (ARB follows U.S. EPA practice in reporting results using both 3% and 7% discount rates.)

Nearly all of the monetized benefits result from avoiding premature death. The estimated benefits from avoided morbidity are less than $400 million with a 3% discount rate and less than $300 million with a 7% discount rate. Most of the benefits, approximately 85 percent, are associated with reduced DPM, and the remaining 15 percent with reduced NOx.

Appendix C discusses the methodology staff used to monetize the value of avoiding the adverse health impacts using valuations compiled from ARB and U.S.EPA publications, updated to 2006 dollars.

D. Climate Change Impacts

In assessing the climate change impact of the proposed regulation, staff examined only the direct emissions from operation of the vehicles. In addition to CO_2, offroad diesel engines emit significant amounts of at least two pollutants associated with climate change – black carbon and ozone-forming NOx. However, it is difficult at this time to estimate the impacts of reductions of these pollutants on climate change. The U.S. EPA did not estimate climate-associated benefits for the new Tier 4 standards for nonroad diesel engines since there is no global warming potential yet assigned to black carbon as there are for gases such as carbon dioxide, methane, and nitrous oxide. The U.S. EPA also stated that it would be important to characterize all of the effects of the rule on climate, including tropospheric ozone and fuel economy, but the methods to conduct such an assessment are not available (U.S. EPA, 2004c). This section provides a general discussion of the impact of the projected emissions reductions on climate change and a rough estimate of the effect of the fuel economy penalty.

1. Greenhouse Gases

The most important class of climate forcing agents responsible for global warming are greenhouse gases (GHG) which are predominantly comprised of CO_2, methane (CH_4) and nitrous oxide (N_2O). Other GHGs include H_2O, carbon monoxide (CO) and ozone (O_3). These gases are known as GHGs, due to their transparency to high frequency solar radiation and their opacity to low frequency infrared radiation emitted from the Earth's surface. The gases differ in their atmospheric warming potential, and as a result, the contribution of each gas is determined as equivalent CO_2 emissions using conversion factors approved by the Intergovernmental Panel on Climate Change. For example, methane has 21 times the warming potential of carbon dioxide and nitrous oxide has 310 times the warming potential of CO_2.

Diesel engines offer better thermal efficiency and fuel economy than their spark ignited counterparts, which leads to lower tailpipe and lifecycle CO_2 emissions. Nitrous oxide is produced as a byproduct of NO reduction and CO/hydrocarbon (HC) oxidation on noble metal catalysts in gasoline vehicle exhaust systems. The effects of catalyzed diesel particulate filters and other diesel exhaust after-treatment devices on N_2O emissions are unknown. However, urea-SCR may generate N_2O.

In evaluating the potential GHG emissions changes and their impacts on climate change, it is relevant to examine changes in CO_2 emissions associated with fuel economy impacts, as well as impacts of particle and aerosol formation and emissions.

a) Fuel Economy

Carbon dioxide emissions from vehicles are directly proportional to fuel consumption, so any changes in fuel economy will have a direct impact on CO_2 emissions. To comply with the proposed regulation, fleet owners would be expected to use the most cost effective combinations of PM retrofits and engine replacements. Both of these actions could result in a fuel economy penalty, however, on the whole, staff expects the regulation to result in a negligible effect on global warming..

In their regulatory impact analysis of the fuel economy impacts of the new Tier 4 standards for nonroad diesel engines, the U.S. EPA states that with the technology options available to the engine manufacturers, nonroad engines will meet the emission-control targets with only a small impact on fuel consumption (U.S. EPA 2004). The average impact of the additional pumping work required to force the exhaust through the diesel particulate filter was estimated to be equivalent to an increase in fuel consumption of approximately one percent. This estimate takes into account the range of exhaust flow conditions that might be encountered with different engine operating conditions. For staff's analysis, a fuel economy penalty of two percent was assumed for the PM retrofits.

The U.S. EPA's analysis assumed that the primary NOx emissions control technology would be NOx adsorbers which would have a negative impact on fuel economy by requiring nonpower-producing fuel consumption to function properly. The fuel consumption rate for NOx regeneration and desulfation of the NOx adsorber was estimated as approximately 2 percent of total engine fuel consumption. Nevertheless, the NOx tradeoff with fuel economy is expected to be a significant improvement over the current NOx control technologies – charge-air cooling, cooled EGR and injection timing control.

Although the U.S. EPA predicted that these small fuel consumption impacts would be eliminated by technology improvements, they nevertheless included the fuel economy impacts in the overall cost analysis for the Tier 4 standards. For the proposed regulation, staff estimated the CO_2 emissions impact of the regulation based on a 2 percent fuel economy penalty for PM retrofits and a 2 percent penalty for new Tier 4 vehicles. The retrofit fuel economy penalty of 2 percent is the same value used in estimating the impact of this penalty on the overall cost of the proposed regulation.

Equation IX-1 was used to calculate the increase in CO_2 emissions due to the fuel economy penalty resulting from PM retrofits and accelerated turnover to Tier 4 engines required by the regulation.

$$\textbf{Equation IX-1 - } CO_2 = \textit{Fuel Increase} \times EMF \times 0.001$$

Where: *CO_2* = Average annual increase in CO_2 emissions due to the fuel Economy penalty (metric tons/year)

Fuel Increase = Increase in annual statewide diesel fuel consumption due to the fuel economy penalty (gallons /yr)

EMF = Emission factor = 9.96 kg CO_2/gallon for California low sulfur diesel (CCAR, 2006)

0.001 = Conversion factor (metric tons/kg)

A fleet that accelerates turnover to a Tier 4 engine because of the regulation would incur the Tier 4 fuel penalty earlier than it normally would. For a given vehicle, the average annual CO_2 emissions increase attributed to the regulation is the increase averaged over the number of years from the accelerated turnover date to the normally scheduled turnover date. The accelerated turnover period was determined by the compliance strategies used in the model of the emissions reductions (Appendix H). An average statewide fuel consumption percentage increase was estimated using the methodology and assumptions described in Appendix I. This average (*Fuel Increase*) for the statewide fleet was used in Equation IX-1 to calculate the CO_2 emissions increase for accelerated turnover. A similar estimate was made for the PM retrofit compliance strategy.

Using an estimated annual diesel fuel consumption of 300 million[24] gallons and an emission factor of 9.96 kg CO_2/gallon of diesel fuel (CCAR, 2006), the estimated increase in CO_2 emissions due to retrofits is approximately 0.2 percent of the total statewide CO_2 emissions from the off-road vehicles covered by the proposed regulation, and the increase due turnover to a Tier 4 engine is less than 0.75 percent of the total statewide emissions.

b) Idling Emissions

The proposed regulation would limit idling of off-road diesel vehicles to five minutes or less unless such idling is necessary for the proper or safe operation of the vehicle. Nonessential idling has an adverse impact on global warming. Limiting unnecessary idling would reduce fuel consumption, and emissions of carbon dioxide – a greenhouse gas and contributor to global warming.

Staff examined the impacts of the idling limits required by the proposed regulation. An estimate was developed for unnecessary idling activity, and this value was then used to determine the fuel and greenhouse gas benefits. On average, off-road vehicles were assumed to consume 0.5 gallons for each hour at idle. It was also assumed that for every gallon of diesel fuel used, 9.96 kilograms of carbon dioxide (CO_2) would be

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[24] This is an approximation as discussed in Appendix I.

produced (CCAR, 2006). Staff estimates that implementation of the idling limit requirement of the proposed regulation would provide fuel savings and CO_2 emissions reductions of approximately 2 percent. The details of the calculations are presented in Appendix I.

c) Net Effect on Greenhouse Gases

The overall impact of the regulation on climate change would be negligible. There would be a net decrease in CO_2 emissions of about 1 percent after taking into account the 2 percent CO_2 benefit estimated for the idling limits, and the relatively small CO_2 increases of 0.2 percent and 0.74 percent for the fuel economy penalty for PM retrofits and accelerated Tier 4 turnover, respectively.

2. Aerosols

Particles, especially those with diameters smaller than 1 µm, can affect the earth's temperature and climate by altering the radiative properties of the atmosphere. "Reflective aerosols" will scatter solar radiation so that a substantial portion of the radiation incident to the Earth's troposphere is returned to space, thereby cooling the climate. Examples of these are sulfates, nitrates, and organic carbon particles.

"Absorbing aerosols" will absorb solar radiation, transfer the energy to the atmosphere, and prevent sunlight from reaching the ground. These aerosols warm the atmosphere, but cool the surface. Black carbon aerosols, or soot, formed by incomplete combustion are absorbing aerosols and cause a positive climate forcing of uncertain magnitude. Current investigations indicate that black carbon and associated organic matter play a major role in climate change, but this role has not been quantified reliably. Modeled estimates for radiative forcing by black-carbon-containing aerosols range widely. It may be the second or third largest individual warming agent, following CO2 and perhaps methane (Bond and Sun, 2005).

Since diesel PM is composed largely of black carbon and associated organic matter, the diesel PM emissions reduction obtained with the proposed regulation would have a positive climate change impact by reducing the black carbon component of global warming. Also, because the lifetime in the atmosphere for most black carbon is short compared to CO_2, the control of black carbon emissions can bring an immediate environmental benefit compared to the slower response to CO_2 emissions controls.

3. Ozone Precursors

It is estimated that tropospheric ozone has had the third largest impact on radiative forcing (1750 to present) of all GHGs. Changes in tropospheric ozone are due to anthropogenic increases in the emissions of ozone precursors – NOx and VOCs. However, the effect of reducing these precursors is still uncertain, as there are no agreed-upon methods for estimating the Global Warming Potential of ozone precursors. Also, ozone production leads to the formation of particulate nitrate and secondary organics which enhance cooling. However, there are no methods for accounting for the indirect effects of changes in tropospheric chemistry. Ozone is short lived in the troposphere (an average lifetime on the order of weeks) and is typically treated as a regional pollutant with direct and indirect climate effects that vary considerably by location.

4. Alternative Fuels

The proposed regulation gives credit for the use of electric and alternative fuel vehicles and systems to replace diesel vehicles. This provision of the rule could have a positive impact on climate change to the extent that it is effective in encouraging owners to purchase low-GHG vehicles or use low GHG fuels where they are cost effective alternatives to conventional diesel vehicles or fuel. While there is a clear greenhouse gas advantage from the need for reduced power generation and fuel production. While there are greenhouse gas implications in battery manufacturing, replacement and disposal. On a lifecycle basis, electric vehicles have lower associated emissions than diesel vehicles (Delucchi, 2005). Over the longer term, expanding the use of electric vehicles would provide the benefit of zero tailpipe emissions, and reduced climate change impacts. This option is not expected to be widely used in construction, but increased use of electric vehicles by the airline industry could have a small positive impact on climate change.

E. Welfare Impacts

In addition to the public health effects of fine particulate pollution, fine particulates including sulfates, nitrates, organics, soot, and soil dust contribute to regional haze that impairs visibility.

In 1999, the U.S. EPA promulgated a regional haze regulation that calls for states to establish goals and emission reduction strategies for improving visibility in 156 mandatory Class I national parks and wilderness areas. California has 29 of these national parks and wilderness areas, including Yosemite, Redwood, and Joshua Tree National Parks. Reducing diesel PM from diesel-fueled off-road vehicles would help improve visibility in these Class I areas.

F. Reasonably Foreseeable Mitigation Measures

ARB staff has concluded that no significant adverse environmental impacts should occur from adoption of and compliance with the proposed regulation. Therefore, no mitigation measures would be necessary.

G. Alternative Means of Compliance with the Proposed Regulation

Alternatives to the proposed regulation are discussed in Chapter 10 of this report. ARB staff has concluded that the proposed regulation provides the most effective and least burdensome approach to reducing exposure of children and the general public to diesel PM and other air pollutants emitted from off-road diesel-fueled engines.

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X. ALTERNATIVES CONSIDERED

Throughout the regulatory development process, staff considered a number of possible rule structures. The alternatives considered and reasons they were rejected in favor of the chosen NOx and PM fleet average approach are summarized in Table X-1 below.

In developing the regulation, staff was striving to achieve the following goals:

- Achieve the maximum, fastest possible, reduction in toxic PM emissions;
- At the same time, maximize NOx reductions to aid in attainment of the PM2.5 standards in South Coast and San Joaquin Valley;
- Minimize the cost for fleets and, in particular, minimize the need for fleets to control equipment twice (for example, by having to turn it over twice during the course of the rule);
- Achieve cost-effective emission reductions on a dollar per ton basis.

Staff sought to achieve these goals while keeping in mind the technology available today and likely to become available over the next decade.

Overall, the NOx and PM fleet average approach, coupled with the minimum annual turnover/retrofitting alternative (i.e., the BACT requirements) was chosen as the best structure. It provides maximum flexibility for fleets to find their own most cost-effective combination of retrofits, repowers, and accelerated turnover that would bring them to compliance. It allows fleets to make decisions concerning which vehicles they plan to keep for a long time versus those that are not worth repowering or retrofitting because they would be turned over soon. It also rewards fleets that start out cleaner, because they would have to do less to reach the fleet average targets. Finally, the minimum annual turnover/retrofitting alternative (the BACT requirements) allows fleets that start out very dirty or that happen to own very long-lived equipment and who cannot realistically meet the fleet average targets, especially in the early years of implementation, to have an affordable path to compliance.

Table X-1 - Alternative Rule Structures Considered

Approach	Why Rejected
No action - allow natural turnover of the statewide fleet to gradually lower emissions over time.	Would not achieve the emission reductions as quickly as needed to meet the state's air quality commitments or public health goals.
Traditional Best Available Control Technology (BACT) PM retrofit rule – Like the solid waste collection vehicle rule, require fleets to phase in a certain percent of PM retrofits per year until all vehicles are retrofit.	Would not offer fleets flexibility to choose the most cost-effective combination of retrofits, repowers, and accelerated turnover. Would not be guaranteed to achieve critically needed NOx reductions.
PM-only fleet average rule – Require fleets to meet a declining PM fleet average	Would achieve significantly less NOx reductions than a combined NOx and PM fleet average.
Mandatory phase-out of the dirtiest engines - Phase out Tier 0s by a certain date, Tier 1s by a later date, etc. and require exhaust retrofits	Could encourage acquisition or holding of Tier 0 and 1s before mandatory turnover starts, which could cause an emissions disbenefit before the rule takes effect and which might achieve very little benefit in the early years of implementation. Lacks the flexibility of a fleet average to allow credit for strategies other than turnovers such as PM or NOx retrofits.
Mandatory NOx retrofit and PM retrofit – A traditional BACT rule with BACT defined as highest level NOx and PM retrofit.	Would achieve less NOx reductions in long-term because vehicles that are retrofit cannot be immediately turned over. There is also uncertainty regarding availability and feasibility of NOx retrofits. Higher cost than PM and NOx fleet average approach. Would eliminate fleet's abilities to choose a cost-effective path to compliance.

The sections below provide further quantification and detail on four alternatives that were considered – using looser fleet average targets, requiring mandatory phase-out of the dirtiest engines, requiring highly effective NOx retrofits such as selective catalytic reduction (SCR) systems, and requiring a higher turnover rate before 2015 for fleets that do not meet the NOx fleet average targets.

A. Looser Fleet Average Targets

During the course of the workshop process, construction industry representatives proposed an alternative with no NOx targets and with much looser PM fleet average targets than those included in the proposed regulation - 0.40 g/bhp-hr PM in 2015, and 0.15 g/bhp-hr PM in 2025. ARB staff evaluated these industry-proposed fleet averages but did not recommend adopting them because, over the life of the regulation, they would achieve less than 20 percent of the PM reductions and less than 45 percent of the NOx reductions expected from ARB's proposal. Table X-2 compares the expected emission reductions in specific years from the much looser PM targets with those expected from the proposed regulation.

Table X-2 - Emission Benefits from Alternative With Much Looser PM Fleet Average Targets Compared to Proposed Regulation

PM Reductions (tons per day)			
Proposal	**2010**	**2015**	**2020**
Proposed Regulation	2.3	6.9	5.2
Alternative	0	2	0.2
% Fewer Emission Reductions from Alternative	100%	71%	96%
NOx Reductions (tons per day)			
Proposal	**2010**	**2015**	**2020**
Proposed Regulation	13	30	48
Alternative	0	13	3
% Fewer Emission Reductions from Alternative	100%	58%	94%

B. Mandatory Phase-out of Dirtiest Engines

Staff also evaluated an alternative proposed by a stakeholder that would have fleets phase out all Tier 0 vehicles by 2015, and then would require fleets to phase out all Tier 1 engines by 2020 and buy only Tier 4 engines and vehicles starting in 2015. Table X-3 compares the emissions benefits from the current ARB proposal with the concept outlined above. The emissions benefits estimated below are if all Tier 0 engines are replaced with Tier 2 engines by 2015, and by 2020 all Tier 1 engines are phased out and replaced with Tier 4 engines. Benefits were not estimated from phasing out additional Tier 2 engines as many would be less than 10 years old. The phase-out alternative would achieve significantly less NOx and PM reductions than the proposed regulation.

In addition, requiring that all Tier 0 vehicles be phased out by 2015 would be economically infeasible for many fleets and could easily exceed the financial ability of fleets that currently have all or nearly all Tier 0 vehicles to comply with such a reqirement. These fleets would have to turnover their engines at rates much higher than the maximum 8 percent per year turnover until 2015 and 10 percent per year after 2015 that is required in the current proposed regulation. The economic impact on fleets who operate newer equipment would be less, and would not be significantly different than the current proposal in terms of turnover requirements.

Table X-3 - Emissions Benefits Comparison of Mandatory Phase-out of Dirtiest Engines (tons per day)

Proposal	2015		2020	
	NOx	PM	NOx	PM
Proposed Regulation	30	6.9	48	5.2
Phase out Alternative	26	1.7	42	2.8
% Fewer Emission Reductions from Alternative	13%	75%	13%	46%

C. Requiring High Efficiency NOx Retrofits

Staff of the SCAQMD proposed an alternative that would have required installation of combination NOx and PM retrofits (such as SCR) whenever a PM retrofit would be required under the PM BACT path. As discussed earlier, high efficiency NOx exhaust retrofits require certain exhaust temperature to work effectively and are likely to be feasible for less than 25 percent of the horsepower in the fleet. However, staff evaluated the potential costs and benefits of this proposed alternative and found that the SCR retrofit alternative could provide modest additional benefits through 2015. However, to maintain comparable NOx and PM reductions after 2020, many vehicles on which SCR would be installed would have to subsequently be turned over and retrofit again. As a result, fleets would likely face the need for double control on these vehicles. If high efficiency NOx retrofits systems do not become available, this proposal could cost several billion dollars more relative to the proposed regulation if the projected emissions benefits had to be made up by engine turnover in excess of 10 percent per year.

D. Requiring More Turnover Before 2015

Staff also evaluated a potential regulation design that would in early years have tighter NOx fleet average targets and a higher percentage required turnover for fleets not meeting the targets (10 percent per year rather than 8 percent in the years up to 2015). As shown in Figure X-1, the alternative would achieve greater NOx reductions in the short-term (before 2015).[25] However, in the long-term and in total over the course of rule implementation, the alternative would achieve significantly less NOx reductions than the proposed regulation because more fleets would be required to purchase Tier 2 and Tier 3 engines before Tier 4 became available. Under the proposed regulation, the cleaner fleets would be able to wait for Tier 4 engines to be available rather than be forced to turn over to Tier 2 and 3 engines as an interim step, and thus would end up with much cleaner engines. As shown in Figure X-1, because its PM provisions would be the same as that of the proposed regulation, this alternative would be expected to

[25] The emission benefit estimates in Figures 1 and 2 were prepared using a preliminary set of sample fleets and also do not include benefits from the idling provisions of the proposed regulation. Therefore, the emission benefit estimates in Figures 1 and 2 do not match exactly the final estimates of emission benefits of the proposed regulation cited elsewhere in this Technical Support Document.

achieve about the same PM reductions as the proposed regulation. Overall, the alternative would cost about the same as the proposed rule but would achieve less long term and total emission reductions and prevent fewer deaths than the proposed regulation.

Figure X-1 - NOx Benefits of Alternative With Tighter NOx Targets and Higher Percent BACT Turnover In Early Years Compared to Proposed Regulation

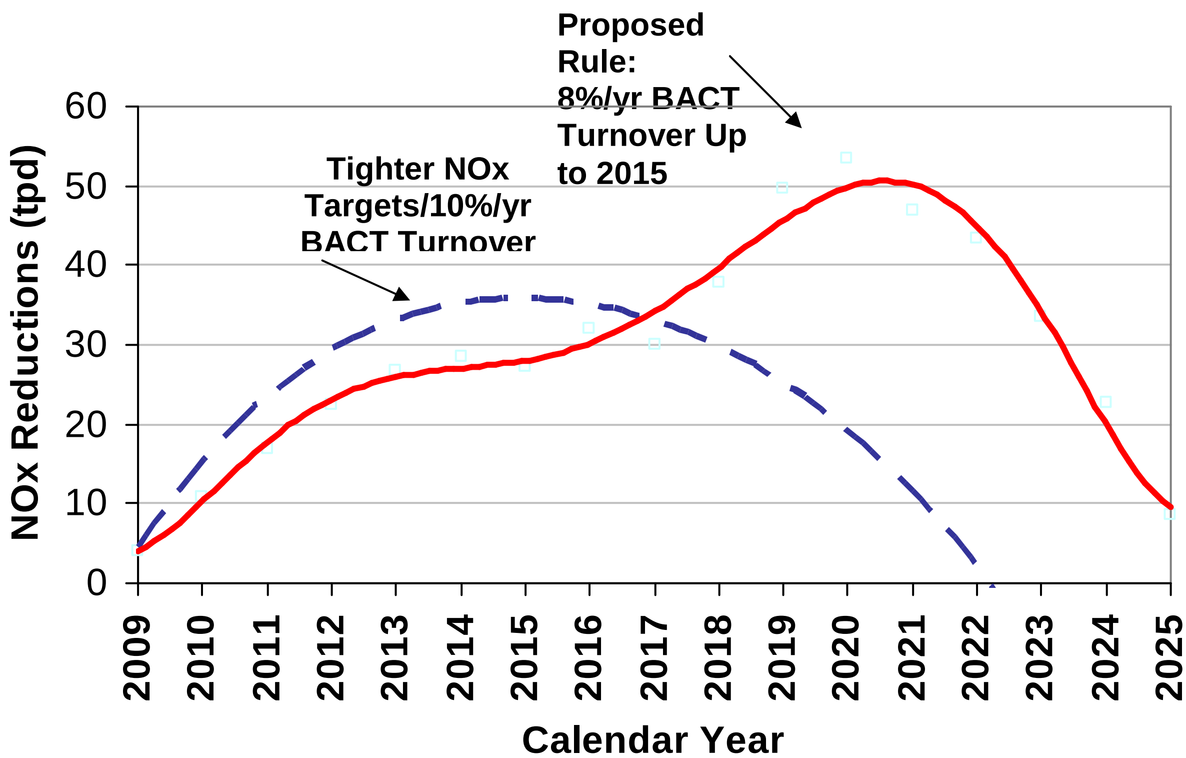
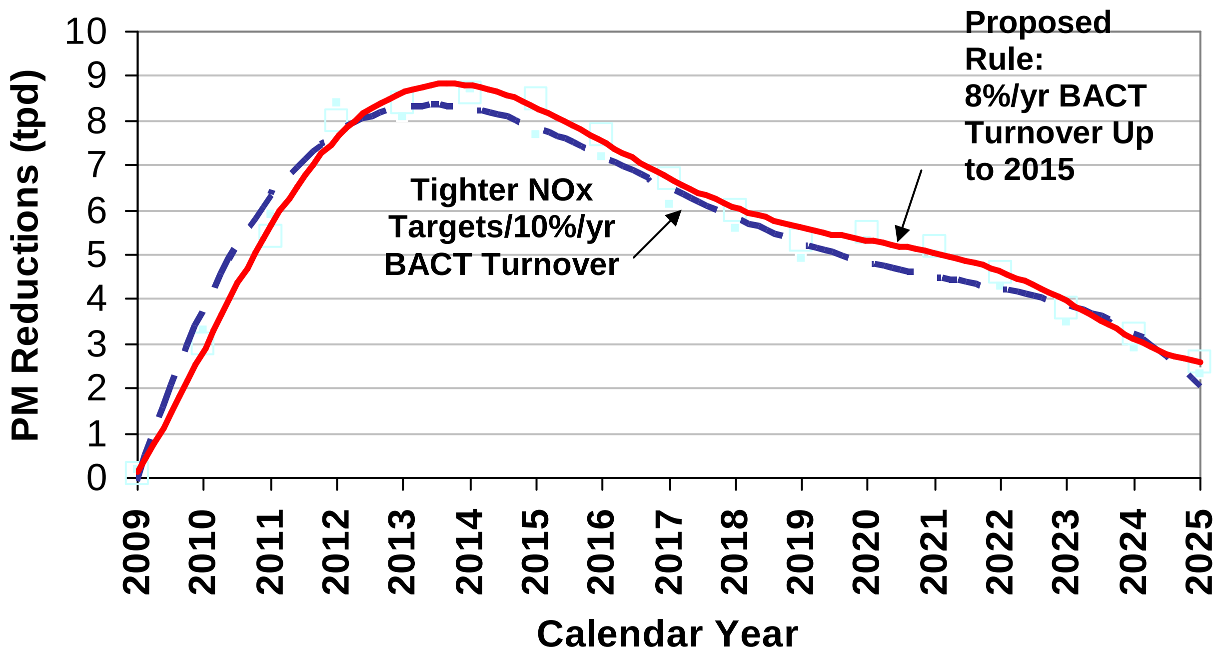


Figure X-2 - PM Benefits of Alternative with Tighter NOx Targets and Higher Percent BACT Turnover In Early Years Compared to Proposed Regulation



XI. COST AND ECONOMIC IMPACT

A. Summary

This chapter discusses the costs and economic impacts of the proposed regulation. Based on staff analysis, the total discounted cost of the proposed regulation (in 2006 dollars) for the statewide fleet is $3.0 billion - $3.4 billion. The economic impacts of the proposed regulation on the State and on the industries affected are not expected to be significant. However, the economic impact on individual fleets would depend heavily on the choice of each fleet to either meet both the PM and NOx fleet averages, or to comply with the best available control technology requirements. For each fleet, the costs imposed by the regulation could include the early replacement of new or used vehicles (accelerated turnover costs), repower costs, exhaust retrofits costs, and reporting costs.

ARB recognizes that compliance with the proposed regulation may be financially challenging for owners of regulated vehicles. Many fleets may have to change how they allocate capital resources, and they may need to borrow money to purchase retrofits and repowers, or to upgrade their vehicles. In addition to the Carl Moyer Program, to minimize the cost-impact of compliance, staff is consulting with other state agencies such as the Pollution Control Financing Authority in the State Treasurer's Office and private lenders to look for ways to leverage existing public programs and funding in the private sector, through potential programs such as government loan guarantees, interest rate buy down programs, etc. It is hoped that these efforts could make compliance with the regulation more affordable and access to capital more widely available. However, ARB does not currently have the funds to help create such programs, and thus their availability remains speculative at this time.

B. Legal Requirements

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

State agencies are also required to estimate the cost or savings to any state or local agency and school districts in accordance with instruction adopted by the Department of Finance. This estimate is to include any nondiscretionary costs or savings to local agencies and the costs or savings in federal funding to the state.

C. Methodology for Estimating Cost and Economic Impact

The economic impacts of this regulation are based on the anticipated compliance paths of approximately 200 affected fleets. Using this data, the costs to the statewide fleet were calculated by predicting and evaluating the compliance paths for real individual fleets using the ARB Off-road Compliance Model (Appendix H). Each fleet evaluated varied by horsepower distribution, age, and vehicle type and provided a representation of the variety of fleets present in the state. The analysis determined the costs beyond those of estimated normal turnover; all costs calculated are additional costs fleets would incur by complying with the regulation.

1. Individual Fleet Analysis

The compliance path for each real fleet included the options of retrofitting, repowering, or accelerating turnover (to new or used vehicles) to meet the PM and NOx fleet averages, or to comply with the BACT requirements each year. For each fleet, the minimum turnover and/or exhaust retrofits required to meet either the BACT requirements or the appropriate fleet average targets. The assumptions and costs for the different aspects of each compliance path are outlined in the sections below.

a) Accelerated Turnover

One compliance option for fleets is to buy a newer replacement vehicle sooner than planned. In taking this action, the fleet incurs an economic cost associated with replacing the vehicle sooner than they normally would (the factor used to reflect the normal replacement age is tied to the vehicle's useful life). The lost economic value from replacing a vehicle earlier than normal is specific to the normal practice of a given fleet. The methodology used to asses the cost of replacing a vehicle prior to the end of its normal useful life in the fleet (which is the turnover cost attributable to the regulation) is shown below in Equation XI-1.

Equation XI-1 - Accelerated Turnover Costs = [(Price – Salvage Price (UL)) x (Years Sold Early/(UL – Age))] – Salvage Price (Early) + Salvage Price (UL)

Where: Price = Price of the vehicle purchased
Salvage Price (UL) = The salvage value of the vehicle at the end of the its useful life (UL) in the fleet
Years Sold Early = The difference between the UL of a vehicle and the age of the vehicle when it is sold (should be a positive number or zero)
UL = The useful life of the vehicle (determined by equipment type and normal turnover rate of the fleet)
Salvage Price (Early) = The salvage value of the vehicle when sold before the end of its useful life
Age = The current age of the used vehicle purchased

To estimate the accelerated turnover cost for each vehicle, the useful life of that vehicle must first be determined. The useful life of a vehicle is the estimated time the vehicle would be useable in a fleet, at the end of which it would be sold or scrapped by the fleet owner.

The number of years sold early was determined by establishing the calendar year for when a given vehicle would normally be turned over and compared to the calendar year the vehicle would be turned over to comply with the regulation. The normal turnover assumptions used in the individual fleet analyses were based on either information provided by the fleet owner or the average age of the vehicles in the fleet evaluated. A fleet with an average age less than 12 years old was presumed to normally buy new vehicles, but fleet with an average of 20 years old was assumed to normally buy 8 year old used vehicles.

The order in which vehicles were turned over in the analysis was based on comparing the age of each vehicle in the fleet to the useful life associated with the vehicle category. For example, in a given fleet, a 20 year old skid steer is expected to be turned over before a 32 year old scraper because the skid steer is already 50 percent beyond the average useful life but the scraper is only 10 percent beyond the average useful life of 29 years. The average useful life for each equipment type was derived from the ARB OFFROAD2007 model and is shown in Table XI-1

Table XI-1 - Statewide Average Useful Life by Vehicle Category

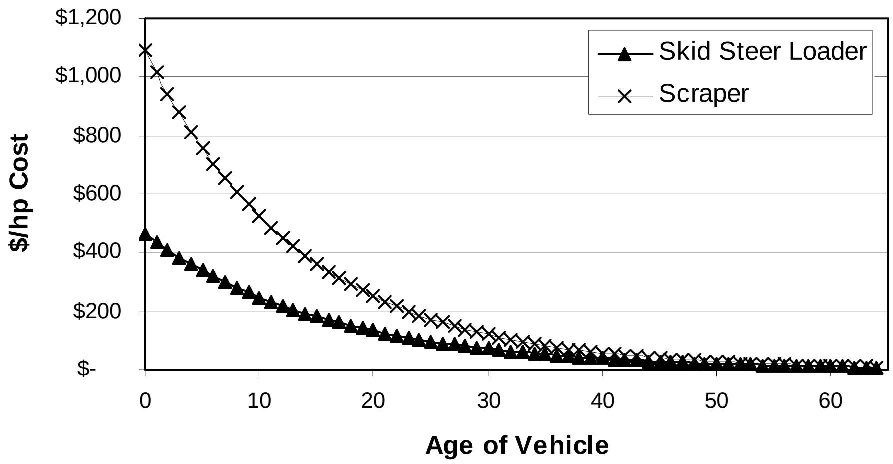
Vehicle Type	Useful Life (Years)
Bore/Drill Rigs	10
Cranes	19
Crawler Tractors	29
Excavators	17
Graders	23
Off-Highway Tractors	31
Off-Highway Trucks	17
Other	16
Pavers	26
Paving Equipment	24
Rollers	20
Rough Terrain Forklifts	16
Rubber Tired Dozers	32
Rubber Tired Loaders	21
Scrapers	26
Skid Steer Loaders	13
Surfacing Equipment	22
Tractors/Loaders/Backhoes	18
Trenchers	28

The average useful lives shown in Table XI-1 result in a statewide average turnover rate (across all vehicle categories) of approximately 5 percent of the statewide horsepower per year (ARB, 2006a). However, for some newer fleets with rapid turnover, the turnover rate would be faster and conversely, for older fleets the turnover rate would be slower. To account for differing turnover rates for individual fleets, a Useful Life Factor

(ULF) was determined for each fleet, based on the average age of the fleet's vehicles (e.g. a fleet that kept its vehicles twice as long as the statewide average would have a ULF of 2).

The new or used vehicle purchase costs, as well as the salvage value at any given year, were determined from for-sale prices of construction equipment types included in the inventory. Prices were plotted by vehicle age and curve fit on a $/hp basis to represent the typical price for each equipment type. Sample curves for skid steer loaders and scrapers are shown in Figure XI-1.

Figure XI-1 - Price Deterioration Curves for Two Vehicle Types



Vehicle prices were compiled from thousands of used vehicle for sale on the www.machinerytrader.com website in late 2006. Table XI-2 lists the average new vehicle price and the used price at the age equal to the statewide average useful life. A complete table of $/hp values by vehicle age can be found in Appendix J.

Table XI-2 - Average Vehicle Price ($/hp)

Equipment Type	Value (new)	Value (age=UL)
Bore/Drill Rigs	$1,501	$497
Cranes	$625	$301
Crawler Tractors	$1,497	$195
Excavators	$1,053	$207
Graders	$758	$263
Off-Highway Tractors	$500	$88
Off-Highway Trucks	$596	$201
Other	$1,000	$243
Pavers	$1,205	$58
Paving Equipment	$1,205	$73
Rollers	$1,073	$286
Rough Terrain Forklifts	$875	$249
Rubber Tired Dozers	$1,172	$64
Rubber Tired Loaders	$797	$220
Scrapers	$1,093	$161
Skid Steer Loaders	$462	$206
Surfacing Equipment	$1,073	$274
Tractors/Loaders/Backhoes	$713	$241
Trenchers	$509	$132

When determining the compliance path for each fleet, the expected normal purchasing practices were incorporated into the purchasing strategy for compliance (e.g., if the current purchase practice of a fleet involved only buying used vehicles, the compliance path chosen for that fleet would also involve purchasing used vehicles). It was estimated that fleets with an average age greater than 12 years old would typically buy used vehicles, while younger fleets would typically buy new vehicles. Also, all of the exemptions proposed in the regulation were modeled (i.e., no vehicles younger than 10 years old were replaced or if a VDEC was installed, the vehicle would not be turned over until the 6 year exemption period passed).

This regulation would increase average statewide turnover to occur at a higher rate than the existing average statewide turnover rate; therefore, there would be greater demand for clean (higher tiered) vehicles throughout the state and less demand for dirty (lower tiered or unregulated) vehicles in the state. Since staff expects off-road vehicles are already purchased and sold in a nationwide (and worldwide) market, fleet owners may buy more vehicles from out of state (or out of country) and bring into California and would sell more dirty vehicles outside California in order to fulfill their compliance requirements. However, to estimate the potential price impact on changes in demand for clean and dirty vehicles, staff estimated a price premium based on the cost to ship sold or purchased vehicles into and out of the state. The transportation cost was estimated at being equivalent to $10/hp, and this cost was added to the price of every vehicle (new or used) purchased for compliance with this regulation.

Increased costs from the accelerated purchase of Tier 4 engines were also included in cost estimates. Tier 4 engines are expected to cost more because of the exhaust after-treatment technology expected to be used in those engines. The 2007 model year on-road truck engine price increased about $7000 compared to the 2006 model year (ATA, 2007). Similar price increases are anticipated with Tier 4 off-road engines. Staff estimated the incremental cost increase for Tier 4 engines to be about half of the price of an aftermarket exhaust retrofit device. This cost premium is reflected in the analysis where a fleet purchases a Tier 4 vehicle early or is required to add more Tier 4 vehicles than it normally would.

Tier 4 vehicles may potentially consume more fuel then lower tiered vehicles, therefore, there are potential fuel penalty costs associated with upgrading to Tier 4 vehicles. On average, staff estimates the 2 percent fuel economy penalty associated with Tier 4 vehicles and accelerated turnover to these vehicles would have a net result of about 0.2 percent for the statewide fleet. Because this small percentage will produce a minimal effect on the overall cost estimates for the regulation, it was not included in the final estimate statewide cost for the proposed regulation.

b) Repowers

Repowering a vehicle to either Tier 2 or Tier 3 standards was also evaluated as a compliance strategy for certain fleets. First, repower options were conservatively assumed to be largely unavailable for many smaller vehicles. In the analysis, vehicles smaller than 250 horsepower were replaced with used vehicles and were not repowered. This is conservative because some manufacturers already have pre-engineered engine kits to repower vehicles less than 100 hp. Second, the analysis method only assumed a repower for vehicles that were turned over more than 10 years earlier than normal. In other words, if the vehicle was already likely to be replaced it is likely that the condition of the rest of the vehicle would not be worth the cost of upgrading the engine and keeping it in the fleet. Repower costs were estimated to average about $270 per horsepower (2007, Justice and Associates).

c) Retrofits

Only Level 3 PM verified diesel emission control systems (VDECS) were considered in this analysis, and the cost per retrofit was based on the horsepower of the vehicle retrofitted. The costs for each horsepower range are shown in Table XI-3.

Table XI-3 - Analysis Cost of Level 3 PM Exhaust Retrofits

Vehicle Horsepower Range	Installed Price
< 50 hp	$8,000
50 to 175 hp	$12,000
176 to 400 hp	$18,000
> 400 hp	$30,000

These prices represent a composite average cost estimate for both passive and active systems, including initial installation costs (ARB, 2006b). Passive systems were assumed to be used in 30 percent of retrofit applications. It is expected that more retrofits will become verified after a regulation would be adopted. It is also likely that the VDEC retrofit market would expand as a result of a regulation and the cost for the VDEC unit and the installation could become lower than those shown in Table XI-3.

Combination NOx and PM systems were also assumed to become available for about 5 percent of the horsepower in the statewide fleet by 2015. These systems were assumed to cost twice that of a Level 3 PM only system and would only be installed when a PM VDEC would otherwise be used to meet the BACT requirements or the PM fleet average. Because of likely cost and size constraints, combination NOx and PM systems were not assumed to be available for engines less than 120 hp.

Vehicles newer than 5 years old are exempt from being retrofit; therefore, these newer vehicles did not receive retrofits as part of this analysis. However, it is likely that some fleets would lower their cost of compliance by installing PM retrofits in vehicles less than 5 years old. Also, the analysis method assumes that fleets would choose to install retrofits on the vehicles they would likely keep rather than install them on vehicles that would need to be turned over in the near term. This would avoid the additional costs imposed by retrofitting an older vehicle, only to turn that vehicle over in 6 years.

d) Filter Regeneration and Annual Maintenance

In addition to the installation and purchase prices of the VDECS, an annual maintenance cost (for filter cleaning) of $400 per retrofit was assumed (ARB, 2006b). A two percent fuel penalty was also estimated for each retrofit installed (ARB 2006b). Additionally, where active VDEC systems were used (70 percent of the installed retrofits), additional costs for regeneration were estimated. Active filter systems are likely to be electrically regenerated (on or off-board), consume fuel to assist or provide regeneration, or filters will need to be swapped frequently if regenerated remotely. The cost associated with these different regeneration options for active systems varies. The mid-cost estimate is based on electric plug in systems. An off-board electrically regenerated system must be plugged into an electrical source. If a unit is regenerated 3 times a week, and consumes 15 kW-hr per regeneration the annual estimated electricity cost is approximately $375/year (Cleaire, 2007). More detailed calculations can be found in Appendix J.

e) Reporting

The regulation is not imposing any direct fees on fleets for reporting (no fees remitted to ARB for registration of equipment). However, because it may be time consuming for a fleet owner to locate all engine/vehicle information necessary for reporting, there would be work time lost (at a cost to the fleet) to gather the fleet information, compile it, then submit it (either electronically or by paper) to ARB staff. Each fleet will have both an initial reporting cost in addition to annual reporting costs until the end of the regulation (at this time, it is estimated that reporting will continue through 2030 for all fleets). The work time lost (or cost for a hired consultant) will be directly related to the number of vehicles in a fleet, in addition to the amount of information the fleet owner already has on record. The estimated costs for a small and typical business are shown in Table XI-4.

Table XI-4 - Reporting Costs

Type of Fleet	Initial Reporting Costs	Annual Reporting Costs
Small	$0 - $400	$50 - $200
Typical (Medium/Large)	$400 - $5500	$200 - $400

It is estimated that a small fleet will need under an hour (for a few vehicles) to a full day (for up to 30 pieces vehicles) to collect the needed information assuming a cost of $50/hr (for a hired consultant or work time lost to collect the needed vehicle information). For a typical fleet, the initial reporting fees were estimated as $400 - $5500, which represents a full day (for small/medium fleets) to almost two weeks (for large fleets) to compile their fleet information. For annual reporting, only changes in the fleet need to be documented and filed; therefore, it will take substantially less time for a fleet to report annually after all the vehicles are initially reported. Annual reporting costs for a small and typical fleet will range $50 - $200, and $200 - $400, respectively. Detailed calculations can be found in Appendix J.

f) Fleet Compliance Options

(1) Cost of Compliance Options

Table XI-5 shows an example of the potential turnover and retrofit cost for a 1987, 300 hp scraper, and a 1997 145 hp dozer.

Table XI-5 - Example Turnover and Exhaust Retrofit Costs (Current Year Dollars, Calendar Year 2009)

Vehicle Type		Useful Life (UL)	Value at end of UL	Used Value in 2006	Cost to Replace w/New	Cost of 2001 Vehicle	Cost To Repower	Retrofit with DPF
1987 300 hp scraper	$/hp	26	$121	$270	$1,093	$563	$270	-
	Total $		$36,300	$81,000	$327,900	$168,900	$81,000	$18,000
1997 145 hp dozer	$/hp	32	$64	$518	$1,172	$815	N/A	-
	Total $		$9,280	$75,110	$169,940	$118,175	N/A	$12,000

For each vehicle in Table XI-5, there are three to four options for compliance with the regulation. The 1987, 300 hp scraper could be repowered or retrofit at a lower cost when compared to buying a new or used vehicle. Although repowering would be a less expensive option, because the vehicle is less than 10 years away from the end of its useful life, it may be more economical to replace with a newer used vehicle. If an older vehicle is repowered, there is a possibility that the entire vehicle will need to be replaced much sooner than if a newer vehicle (instead of a newer engine) had been purchased. For the 1997, 145 hp dozer, repowering was not considered (only engines larger than 250 hp were considered for repower).

(2) Compliance for a Fleet

For a younger fleet with normal turnover to new vehicles at a rate higher than 8 percent of the fleet horsepower per year, the NOx requirements would not add any costs nor require a change in the normal turnover. The turnover rate of 8 percent per year would meet the BACT requirements until 2015 and the fleet would almost certainly meet the NOx fleet average targets from 2010 until 2020. To satisfy the PM requirements a fleet with a turnover rate equal to 8 percent is likely to need to install PM exhaust retrofits on 20 percent of its total hp for the first 1 to 2 years before meeting the PM average targets. Once the PM averages are met, few PM retrofits would be required in subsequent years. For fleets with turnover rates over 12 percent, the fleet would likely meet the PM fleet average target before installing PM retrofits on 20 percent of its total horsepower.

For most older fleets with a normal turnover rate below 3 percent of the fleet horsepower per year to used vehicles, the NOx and PM requirements will most likely only be fulfilled by complying with the BACT requirements for a number of years. This means that most older fleets will comply in the earlier years with 8 percent turnover of the total fleet horsepower per year, and 20 percent retrofit of the total fleet horsepower per year. After the first three years, the fleet would likely meet the PM fleet average, and would be able to comply with the PM fleet average targets in subsequent years with PM retrofits on much fewer than 20 percent of the fleet horsepower. The fleet, likely would not meet the NOx average for at least 6 or 7 years and would need to comply with the BACT turnover requirements. Such a fleet could meet the NOx averages sooner if it always turned over to new vehicles to comply, but could take much longer to meet the NOx averages if it always turned over to used vehicles older than 5 years.

The compliance path for affected fleets is further illustrated below with two sample fleets. Example fleet 1 is an older fleet (average vehicle age of 13.4 years), that has 105,455 horsepower, and has a normal turnover rate of 3.6 percent of the fleet’s horsepower per year. Fleet 2 is a newer fleet (average vehicle age of 8.9 years), that has 14,067 horsepower, and has a normal turnover rate of about 5 percent of the fleet’s horsepower per year.

Table XI-6 - Compliance Path for Example Fleet 1

CY	Horsepower Turnover	Horsepower Retrofit	NOx Target	NOx Average	PM Target	PM Average
2010	8.2%	20.8%	6.02	6.53	0.21	0.32
2011	7.8%	17.3%	5.62	5.78	0.21	0.21
2012	6.5%	9.9%	5.21	5.18	0.16	0.16
2013	3.8%	0.0%	4.81	4.80	0.16	0.14
2014	5.7%	0.0	4.41	4.38	0.12	0.11
2015	5.0%	0.0	4.01	4.01	0.12	0.09
2016	6.3%	0.0	3.60	3.59	0.09	0.08
2017	4.9%	0.0	3.20	3.16	0.09	0.07
2018	4.6%	4.1	2.79	2.77	0.07	0.06
2019	6.2%	0.0	2.38	2.36	0.07	0.06
2020	8.1%	19.3	1.98	1.98	0.03	0.04

The compliance path for example fleet 1 is shown in Table XI-6. To comply with the NOx requirements, the average turnover per year was increased from 3.6 percent to 5.8 percent. For the first two years, the NOx fleet averages were not met; however, the NOx requirements were fulfilled by completing an average turnover of 8 percent per year (BACT path). After 2011, the NOx fleet averages are met every year with less turnover than is required by the BACT path (8 percent in the early years, then 10 percent thereafter). By 2020, about 70 percent of the fleet's horsepower would be turned over; however, 43 percent of the turnover can be attributed to normal turnover practices.

To comply with the PM requirements, Fleet 1 is on the BACT path for the first year, and retrofits 20 percent of the fleet's horsepower. However, in 2011, the PM fleet average is met before the 20 percent has been retrofitted (BACT path), so the PM requirements for that year have been met. In the subsequent years, the PM fleet averages are met with little to no additional retrofits, and in the last year, the remaining vehicles in the fleet must be retrofit (in this case, another 19 percent of the fleet's horsepower). By 2020, 16 percent of the fleets horsepower would be Tier 4 and Tier 4 interim vehicles, and the remaining 84 percent of the fleet's horsepower would be equipped with exhaust retrofit devices.

Table XI-7 - Compliance Path for Fleet 2

CY	Horsepower Turnover	Horsepower Retrofit	NOx Target	NOx Average	PM Target	PM Average
2010	5.0%	21.1%	6.48	6.35	0.42	0.46
2011	4.7%	8.2%	6.10	5.83	0.42	0.42
2012	3.6%	19.0%	5.64	5.46	0.32	0.32
2013	3.4%	0.0%	5.24	5.24	0.32	0.29
2014	8.1%	15.1%	4.83	4.75	0.19	0.19
2015	7.1%	0.0%	4.45	4.43	0.19	0.12
2016	6.8%	0.0%	4.00	3.99	0.15	0.07
2017	8.5%	0.0%	3.59	3.65	0.15	0.05
2018	6.1%	0.0%	3.19	3.11	0.10	0.05
2019	5.3%	0.0%	2.75	2.72	0.10	0.04
2020	7.0%	0.0%	2.39	2.34	0.06	0.04

The compliance path for example fleet 2 is shown in Table XI-7. Because Fleet 2 is a younger fleet, the average percent turnover per year was increased from 5.0 percent to only 5.6 percent. For every year, the NOx fleet averages were met by completing less turnover than is required by the BACT path. Therefore, the NOx requirements were fulfilled meeting the NOx fleet averages. By 2020, about 67 percent of the fleet's horsepower would be turned over, however, 60 percent of the turnover was attributed to normal turnover practices.

For PM, Fleet 1 is on the BACT path for the first year, and installs exhaust retrofits on 20 percent of the fleet's horsepower. However, in 2011, the PM fleet average is met before the 20 percent has been retrofitted (BACT path), so the PM requirements for that year have been met. In the subsequent years, the PM fleet averages are met with little to no retrofitting, and in the last year, there are no remaining vehicles (that are not Tier 4 vehicles) to be retrofit. By 2020, 31 percent of the fleets horsepower would be Tier 4 and Tier 4 interim vehicles, and the remaining 69 percent of the fleet's horsepower would be equipped with exhaust retrofit devices.

2. Statewide Analysis

For each fleet analyzed, the normal turnover for each year from 2010 to 2030 was determined and compared to the turnover and retrofits required by the regulation (compliance path) over the same period. The net present value (NPV)[26] of the total cost per fleet (in 2006 dollars) was then divided by the total horsepower in the fleet, resulting in a $/hp compliance cost for each fleet. The $/hp compliance costs for each fleet were sorted according to fleet average age and fleet size, and compiled using the horsepower distribution in Table XI-8 to determine the overall statewide cost.

[26] NPV = 1/(1+r)^(n+1), where r = the annual interest rate, and n= the number of years in the future. An annual 5 percent real interest rate is the basis of all economic impacts, assuming 7 percent nominal interest rate and 2 percent inflation rate.

Table XI-8 - Horsepower Distribution by Fleet Age

Horsepower Distribution in the Two Hundred Fleets						
Fleet Size	Average Fleet Age					
	0-3.999	4-7.999	8-11.999	12-15.999	16-19.999	20+
Small	0.04%	0.36%	0.65%	0.65%	0.57%	0.37%
Medium	0.07%	0.53%	1.02%	0.22%	1.49%	1.29%
Large	0.58%	15.43%	32.41%	26.66%	15.69%	1.96%

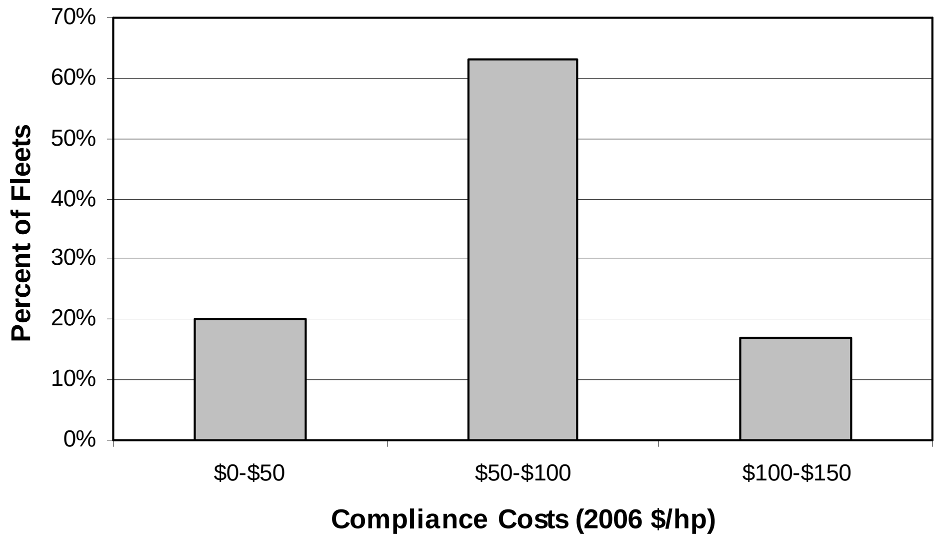
Table XI-8 represents the average age distribution (by horsepower) of fleets compiled from data from over 200 fleets[27]. This represents the mix of fleet ages and horsepower in the statewide fleet. Approximately 16 percent of the horsepower is in fleets with an average age of 4 to 8 years and less than 1 percent is in fleets with an average age less than 4 years. Thus, about 17 percent of the statewide horsepower is in fleets that normally turn over to new vehicles at a rate greater than 6 percent of its total horsepower. The costs (in 2006 $/hp) for the real individual fleets are presented in the following sections. The population of the 200 fleets is 10,152 vehicles representing 2,163,669 horsepower.

D. Estimated Cost to Businesses and Statewide Fleet

Figure XI-2 below shows a compilation of baseline, or hardware costs (costs for accelerated turnover, repowers, and exhaust retrofits) incurred by each of the 200 fleets analyzed. A majority of fleets in the state will experience compliance costs between $50 and $100; less than 20 percent of the fleets are expected to incur costs greater than $100/hp. Less than 1 percent of fleets are expected to incur compliance costs greater than $150/hp.

[27] The data from the 200 fleets was taken from the 2003 TIAX survey, individual fleet owners, and construction associations.

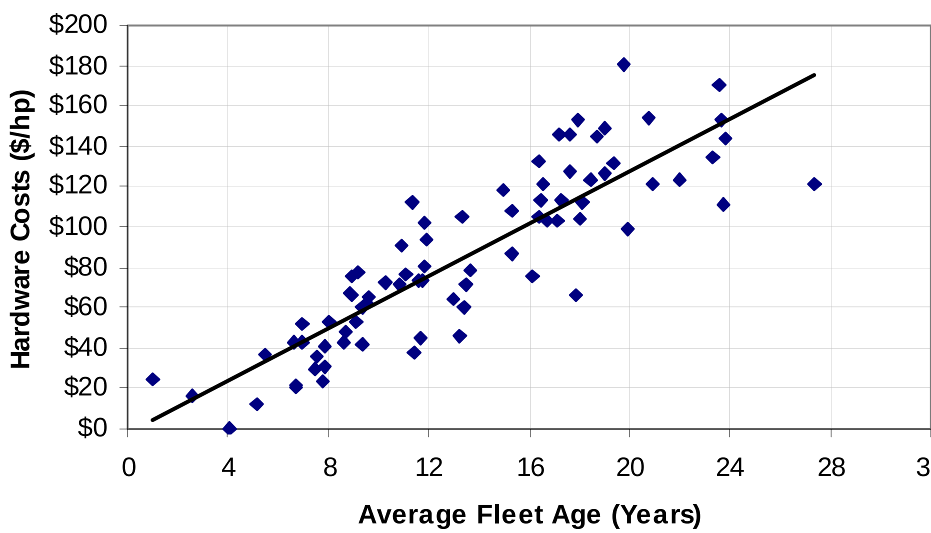
Figure XI-2 - Distribution of Fleets by Regulation Cost



1. Costs for Medium and Large Fleets

The total hardware costs (in 2006 $/hp) including costs for accelerated turnover, repowers, and exhaust retrofits for each medium and large fleet analyzed is shown in Figure XI-3. Maintenance and reporting costs are not included in the figure.

Figure XI-3 - Compliance Costs by Fleet Age for Medium and Large Fleets

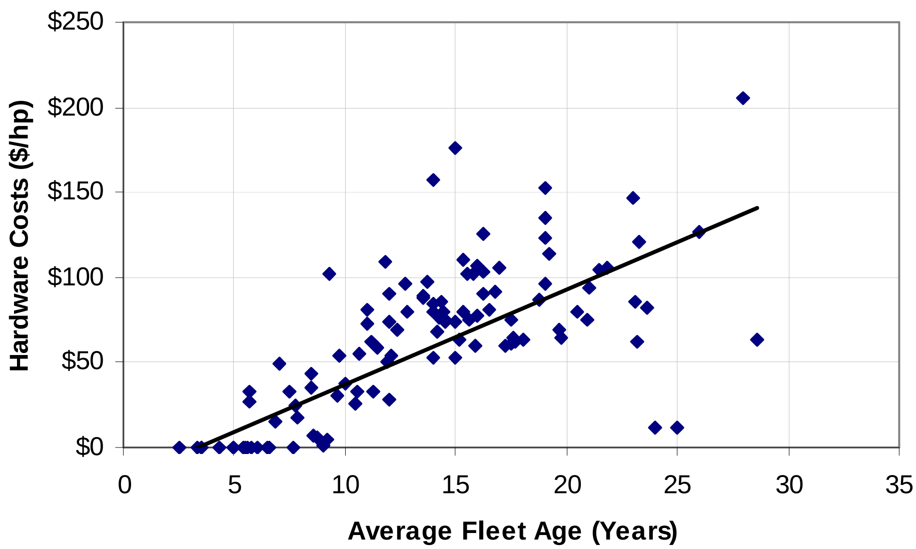


From Figure XI-3, it can be seen that as the age of the fleet increases, the $/hp cost for the fleet will also increase. For fleets with natural turnover rates close to 8 percent of the fleet horsepower per year to new vehicles (such as many rental fleets), the NOx requirements would already be fulfilled by meeting the fleet average targets for through normal turnover, and the PM requirements would result in lower PM retrofit costs compared to older dirtier fleets (hence the lower compliance cost for younger fleets).

2. *Costs for Small Fleets*

Fleets subject to the small fleet category requirements (no turnover required) generally have lower compliance costs, but also have more variation. The total hardware costs (in 2006 $/hp) including costs for exhaust retrofits for each small fleet analyzed is shown in Figure XI-4. Maintenance and reporting costs are not included in the figure.

Figure XI-4 - Compliance Costs by Fleet Age for Small Fleets



There are several fleets modeled with a single vehicle. If such a fleet were to normally turn-over the vehicle to one with an engine meeting the Tier 4 Interim or Tier 4 engine standard before 2015, the cost of compliance would be zero. All Tier 4 engines and most Tier 4 Interim engines will come with DPFs. Fleet who have very slow turnover rates and still have mostly Tier 0 engines in 2015 would generally have the highest costs. Fleets with some newer vehicles would have lower costs of compliance.

3. *Total Statewide Costs*

The statewide costs were estimated by taking a weighted average of the costs of 22 sample fleets selected from the 200 fleets. Each selected fleet within an age size bin was assumed to be representative of the age size bin as a whole and therefore the percent age size bin was taken as the weighting factor for the fleet. The 2006 $/hp costs by age for each fleet type are shown below in Table XI-9.

Table XI-9 - Expected Total Regulation Cost for Fleets with Various Initial Average Ages (2006 $s)

Initial Average Fleet Age (years)	Small Fleets ($/hp)	Medium Fleets ($/hp)	Large Fleets ($/hp)
Less than 8	0-50	0-50	0-50
8 to 12	0-110	40-110	40-115
12 to 16	0-110	75-120	75-130
16 to 20	0-150	75-150	110-150
20 and up	0-150	110-150	110-180

The results from the individual fleet analysis (Table XI-9) were weighted using Table XI-8 to estimate the total statewide cost of the regulation. Table XI-10 contains the total statewide cost of this regulation, as well as costs of each of its components (e.g., maintenance costs, electricity costs, etc.). All costs are shown in 2006 dollars

Table XI-10 - Total Statewide Costs for Regulation

Total statewide cost ($)	$3.0 billion - $3.4 billion
Accelerated Turnover, repower, and retrofit costs	$2.2 billion - $2.6 billion
Initial reporting cost ($)	$25 million
Annual reporting costs ($/year)	$8 million per year
Total reporting costs (through 2030) ($)	$33 million
Retrofit maintenance costs ($)	$379 million
Fuel penalty costs (due to Retrofits) ($)	$70 million
Electricity costs (due to Retrofits) ($)	$144 million

A more detailed outline of the costs can be found in Appendix J. The total statewide costs are estimated to be between $3.0 and $3.4 billion. The total costs include the turnover, repower, and retrofits requirements of the regulation, and also include all maintenance, and reporting costs.

4. Compliance Cost Examples

Costs to individual fleet owners vary depending on the size of each fleet, its initial vehicle composition and vehicle age, and its normal purchasing practices. Costs also vary depending on the compliance strategy chosen by each fleet (retrofit, repower, retire, buy new, and/or buy used). For a typical fleet (here estimated as a medium/large fleet 1,500<hp<22,000), total costs are expected to be $111 per hp (in 2006 dollars). Fleets could incur costs anywhere from $0 to $180 per hp, depending on their initial age distribution, vehicle types and normal turnover rates. For a typical medium-sized fleet with total fleet horsepower of 3,000 hp, the total cost of the regulation is expected to be about $333,000 (in 2006 dollars).

The total cost for compliance with the regulation can also be separated into types of costs: capital costs and ongoing costs. The capital costs include the costs for accelerated turnover, repowers and retrofits needed for compliance throughout the life of the regulation, as well as initial reporting costs. The annual ongoing costs for affected fleets would be annual reporting, and other annual costs due to retrofits (e.g., maintenance, fuel penalties, and electricity costs for active filters).For a typical business fleet, the initial cost would also depend on the actual number of vehicles in the fleet, and how much of the needed reporting information the fleet owner already has compiled; typical fleets would most likely have over 30 vehicles. The initial reporting cost for a typical business is estimated to be $375 to $5,500, depending on fleet size (an average cost of $2,900 was used for a typical fleet). Capital costs for a typical business would be the cost to comply with the regulation, which includes accelerated turnover, repower, and retrofit costs. The capital costs for a typical fleet to comply with the regulation (compliance costs and initial reporting costs) would be approximately $87/hp (out of a total compliance cost of $111/hp). For a typical business, this total cost would be experienced between 2010 and 2020.

The remaining costs for a fleet are the ongoing costs. Ongoing costs for typical business would be additional retrofit costs (e.g., maintenance, fuel penalties, and electricity costs for active filters) and annual reporting costs. Continuing costs for a typical business would be approximately $2.30/hp per year (and constitute the remaining portion of the $111/hp total compliance cost). It is expected that these annual costs would continue from 2010 until 2030 for typical fleets (20 years).

5. Costs for a Small Fleet

For a small fleet (here estimated as also being a small business and < 1500 hp), total costs are expected to be $73 per hp (in 2006 dollars). Fleets could incur costs anywhere from $0 to $1500 per hp, depending on their initial composition and vehicle age. For a typical small fleet with total fleet horsepower of 1,000 hp, the total cost of the regulation is expected to be about $73,000 (in 2006 dollars).

Similarly to a medium/large fleet, the total cost for compliance with the regulation can be separated into both capital costs and annual ongoing costs. For a small business (which is estimated to have between 1 and 30 vehicles), the cost of initial reporting would result from the need for the fleet owner to take a day off of work to inventory his fleet, or the cost of hiring someone outside the business to compile the fleet information necessary for reporting. The initial reporting cost for a small business is estimated to be $50 to $375. The average capital cost for a small business would be the total cost for all retrofits needed to comply with the regulation. For a small fleet, the total initial costs (retrofit costs and initial reporting costs) would be approximately $52/hp (out of a total compliance cost of $73/hp). For a typical small business, this total cost would be experienced between 2015 and 2025.

Typical ongoing costs for small business would be additional retrofit costs (e.g., maintenance, fuel penalties, and electricity costs for active filters) and annual reporting costs. Continuing costs for a small fleet would be approximately $1.70/hp per year (and constitute the remaining portion of the $73/hp total compliance cost). It is expected that these annual costs would continue from 2010 until 2030 for small fleets (20 years).

E. Costs to Local, State, and Federal Agencies

1. Costs to Local Government

Local government fleets represent approximately 3 percent of the statewide fleet total horsepower (TIAX, 2003). It is estimated that 81 percent[28] of the horsepower owned by local government would either have to comply with the NOx and PM fleet averages or meet BACT requirements. This horsepower is typically concentrated in the larger city and county fleets. Of the remaining local government horsepower about 16 percent of the horsepower would meet the low population county criteria and would only be subject to small fleet criteria. In addition, some of the local government fleets (about 3 percent) would be considered captive attainment area fleets, and would only be required to meet the PM portion of the fleet averages or BACT path requirements. Table XI-11 shows the percentage of local government horsepower expected to meet the low population and captive attainment fleet requirements.

Table XI-11 - Local Government Fleet Horsepower Distribution

Fleet Type	Estimated Number of Fleets	Horsepower (hp)	Percent of hp
Local Government Fleets	452	764,390 hp	81 %
Low Population County Local Municipality Fleets	19	155,355 hp	16 %
Captive Attainment Area Local Municipality Fleets	13	29,871 hp	3 %
Total	484	945,881 hp	100 %

Assuming that the age distribution of local government fleets would be similar to the statewide fleet distribution, the total local government costs were calculated in the same method as the total statewide fleet costs. The total costs for local governments between 2009 and 2030 imposed by this regulation are shown in Table XI-12. More detailed calculations are included in Appendix J.

[28] Calculations shown in Appendix G

Table XI-12 - Local Government Fleet Costs

Fleet Type	Low Cost (2006 $)	High Cost (2006 $)
Low Population County Local Municipality Fleets	$9,648,000	$10,897,000
Captive Attainment Area Local Municipality Fleets	$2,442,00	$2,732,000
Remaining Local Government Fleets	$82,999,000	$92,854,000
Total	$95,088,000	$106,483,000

It is expected that the costs for a typical local government fleet would be between $101/hp and $113/hp. A listing of total horsepower and estimated costs for local government fleets that completed the 2003 TIAX survey can be found in Appendix J.

2. Costs to State and Federal Agencies

State fleets affected would include state prisons, state schools and universities, the California Department of Transportation, the Department of Water Resources, and all other California agencies with diesel off-road vehicles. It was estimated that the age distribution of state government fleets would be similar to the statewide fleet distribution. The total state government costs were calculated in the same method as the total statewide fleet costs. The costs for state governments that would be imposed by this proposed regulation are shown in Table XI-13.

Table XI-13 - State Government Fleets Costs

Fleet Type	Estimated Number of Fleets	Horsepower (hp)	Low Cost (2006 $)	High Cost (2006 $)
State Government Fleets	19	461,242	$48,467,000	$54,442,000

The estimated cost for a state government fleet is $105/hp to $118/hp.

In addition to the above identified costs to state agencies, ARB staff is requesting additional staff to conduct outreach and education for fleet owners, and to develop and implement the reporting tools the rule would rely upon, to manage the reporting data once it begins to be reported to ARB, and to assist Carl Moyer incentive program staff with off-road funding qualification questions. In addition, ARB plans to request additional new staff to ensure compliance with the regulations and to build and prosecute enforcement cases.

Federal government fleets affected would include, but are not limited to, the Department of Defense (DOD), federal prisons, national parks, forests and monuments, the Army Corps of Engineers, and any other federally run agency with diesel off-road equipment.

Because there were no federal agency respondents in the 2003 TIAX survey, staff was unable to perform an estimate of total costs to federal fleets. However, the costs are expected to be similar to the state government fleet cost of $105/hp to $118/hp.

F. Sensitivities in Estimating Statewide Costs

The total economic costs imposed by this regulation on the statewide fleet would depend on the compliance path chosen by each business and the compliance options available to them.

1. Retrofits

Staff did not assume PM exhaust system prices would decline in the future. As diesel particulate filters become common place in millions of on-road trucks and in thousand of retrofit applications, it is expected that the cost of exhaust systems would decrease (including maintenance and installation costs) over time. These potential price declines would decrease staff's cost estimates of the regulation.

Currently, there are a number of NOx control systems being demonstrated in on-road and off-road vehicles. Further, on-road diesel engine manufacturers are developing exhaust emission control systems to reduce NOx and PM to meet the 2010 on-road engine standards. The expected installed price for NOx and PM combination retrofit systems is already much lower than the cost of an engine repower. Although a small percentage of NOx retrofits (5 percent) were used for this analysis, when they become more readily available they are expected to be widely used and would result in additional emissions benefits and would lower the cost of compliance than currently estimated.

2. Repowers

Repowers to Tier 2 and 3 engines are technologically feasible at this time, and were considered compliance options in this analysis. Tier 4 engines have not been developed, and were, therefore, not considered in this analysis; however, if Tier 4 repowers become available in the future, they may become a more cost effective option to comply rather than purchasing Tier 4 vehicles. This would reduce the overall cost of the regulation.

3. Accelerated Turnover

The turnover requirements imposed by the regulation would require a maximum of 8 percent of the statewide fleet's horsepower to turn over per year until 2015. After 2015, although individual fleets would have to turn over as much as 10 percent of their horsepower per year, most fleets would meet the fleet averages and few would need to do the maximum turnover. The baseline natural rate of turnover of the statewide fleet is about 5 percent per year. Thus, the regulation would at most require 3 percent more turnover per year than normal. The regulation affects about 180,000 vehicles so an increase in demand for Tier 2 or better vehicles and engines in California would represent about 5,400 vehicles per year.

To evaluate whether there is sufficient supply of used vehicles to meet this new California demand, staff compared the number of used off-road vehicles recently for sale on two used equipment websites on a single day. On these two sites, there were over 80,000 vehicles for sale and over 30,000 of them were 2003 model year or newer (likely Tier 2 or better) (Ritchie Brothers, 2007; Machinery Trader, 2007). By the time the first requirements for accelerated turnover take effect in 2010, there is likely to be an even greater number of Tier 2 or better used vehicles available. Based on this evaluation, it appears likely that there would be a sufficient number of used vehicles available to meet the increased demand due to the regulation. Based on this analysis staff did not see the need to collect annual used equipment sales data from California dealers or other sources. However, it is possible that certain vehicle types may have limited availability of cleaner used vehicles, and individual fleets with those vehicles may have higher costs of compliance once other vehicles in their fleet have been turned over.

Staff also believes enough new vehicles would be available to satisfy the regulation requirements. This demand in the context of the national and international market for off-road diesel vehicles is small. In 2005, there were over 329,000 new off-road construction vehicles sold in the United States. If all fleets were to comply with the regulation by buying new vehicles, the increase in demand for new vehicles in California would represent less than 3 percent of national sales.

To evaluate the availability of new engines and vehicles, staff also visited equipment manufacturers in the Midwest to assess the manufacturer's ability to meet future effective engine standards and their ability to satisfy potential increased demand. Manufacturers indicated that there would be sufficient new engines available to meet demand and that they would respond to market conditions.

Finally, the regulation would contain provisions so that fleets are not penalized if manufacturer delays prevent them from acquiring the equipment or vehicles they need to comply. Also, the proposed regulation contains special provisions that would exempt from the mandatory turnover requirements specialty equipment for which repowers and used vehicle replacements are not available.

G. Economic Impacts

1. Impacts on the California Economy

Developing control cost estimates provide a means to estimate the direct expenditures that would be incurred by California businesses, governments, and individuals to meet the requirements in the proposed regulation. Depending on the significance of these costs, they could in turn bring about additional (indirect) changes in the California economy. Increased control costs for all off-road vehicles, for example, may result in higher prices to perform certain services. California firms may respond by cutting back production and decreasing employment. On other hand, the requirements in the proposed regulation may also increase demand for retrofitting, repowering, and new off-road equipment, thus inducing firms supplying those products and services to expand their production and increase their hiring of workers.

This change in economics could in turn affect other industries both negatively and positively. The net effect on the California economy of these activities hinges on the extent to which products and services are obtained locally. Using a new version of the E-DRAM model (a macroeconomic model of the California economy), staff estimated the net effects of these activities on affected industries and the overall economy. The California industries affected most are those engaged in the use of off-road equipment such as the construction and mining industries. Also affected are industries that are engaged in retrofitting, repowering, or replacing off-road equipment.

The economic model used for this analysis does not account for the significant health benefits to California businesses and citizens that this regulation would bring. Actions to improve air quality reduce illness and premature death, and increase natural resources and work force productivity there by providing significant societal cost savings. This regulation is also likely to induce significant advancement of clean diesel engine technologies by California based companies. ARB staff estimates that the benefits to California of currently adopted air pollution control measures exceed their costs by about 3 to 1. That is, each dollar spent on clean air generates on average three dollars in social benefits that improve the quality of life.

a) Direct Costs

The proposed regulation imposes costs on a number of industries; the most costly year of the regulation was used for this analysis ($568 in 2010). Estimates of total annual costs for each affected industry are provided in Table XI-14. As shown in the table, about 50 percent of the compliance costs would be borne by the construction industry, 14 percent by business services, 11 percent by mining, 13 percent by utility and landscaping, and the balance by other industries and state and local governments.

Table XI-14 - Estimates of Total Annual Costs of Proposed Off-Road Equipment Regulation by Affected Industries for 2010 (Millions of 2006 Dollars)

Industry	Annual Costs	Percentage
Air Transportation	$5.7	1%
Business Services	$79.5	14%
Construction	$283.9	50%
Government Spending on Transportation	$22.7	4%
Landfill	$5.7	1%
Landscaping	$34.1	6%
Mining	$62.4	11%
Miscellaneous Manufacturing	$11.3	2%
Recreation and Entertainment	$5.7	1%
Retail Trade	$5.7	1%
Transportation	$11.3	2%
Utility Infrastructure Construction	$39.7	7%
Total	$567.7	100%

b) Environmental-Dynamic Revenue Analysis Model (E-DRAM)

The overall impact of all direct and indirect economic effects associated with the proposed off-road equipment regulation is estimated using a computable general equilibrium (CGE) model of the California economy. A CGE model simulates various economic relationships in a market economy where prices and production adjust in response to changes in behavior resulting from regulatory changes. More specifically, it describes the relationships among producers, consumers, government, and the rest of the world. The CGE model used for this analysis is the latest updated version of the E-DRAM. E-DRAM was first developed as DRAM for the California Department of Finance[29]. The model can be used to measure the total impact of a change caused by a regulation in one industry on all other industries within California. The economic impact results are measured in terms of changes in the State output, personal income, and employment.

The new model is based on a revised database called a social accounting matrix (SAM). The revisions to SAM include a calibration of the base year in the model to calendar year 2003 from fiscal year 1998-1999, an updating of energy data, and a more detailed sectoring of the California economy. The new E-DRAM divides the California economy into 174 distinct sectors, consisting of 108 industrial sectors, 2 factor sectors (labor and capital), 8 household sectors (classified by income level), 9 composite goods sectors, 1 investment sector, and 45 government sectors (7 federal, 27 State, and 11 local), and 1 sector that represents the rest of the world.

[29] For a complete description of DRAM, see Berck, Peter, E. Golan and B. Smith, "Dynamic Revenue Analysis for California, California Department of Finance, Summer 1996.

Data for the industrial sectors originated with the Bureau of Economic Analysis of the U.S. Department of Commerce, based on the Census of Business – a detailed survey of companies conducted in the U.S. every five years. The conversion of national data to updated California data is accomplished by Impact Analysis for Planning (IMPLAN), a program that primarily utilizes state-level employment data to scale national-level industrial data down to the size of a state.

In much the same way as firms, households are also aggregated. California households were divided into categories based upon their taxable income. There are seven such categories in the model, each one corresponding to a California personal income tax marginal tax rate (0, 1, 2, 4, 6, 8, and 9.3 percent). Thus, the income for the "one-percent" household is calculated by adding up the income from all households in the one-percent bracket.

Similarly, the expenditure of the one-percent household on agricultural goods is calculated by adding up all expenditure on agricultural goods for these households. The total expenditure on agricultural goods is found by adding the expenditure of all households together.

c) Overall Economic Impact

Increased costs of the proposed in-use off-road diesel vehicle regulation would affect the California economy through many complex interactions. E-DRAM was developed to simulate many of these complex interactions. Using the model, ARB staff in consultation with U.C. Berkeley researchers conducted an assessment of the economic impacts of the proposed regulation on the California economy.

Table XI-15 summarizes the impact of the proposed regulation on the California economy in the year 2010, when the annual costs to the affected industries were the highest. We project the costs of the proposed regulation would reduce California economic output by roughly $700 million (0.02 percent) and California employment by approximately 1,000 jobs (0.01 percent) in 2010. Personal income would also decline by roughly $2.3 billion (0.2 percent) in 2010.

Table XI-15 - Impact on the California Economy of Proposed Off-Road Equipment Regulation in the Year 2010 (Billions of 2006 Dollars)

California Economy	Without Regulation	With Regulation	Difference (Impact)	Difference (Percent)
Output	$2,652	$2,651	-$0.7	-0.02%
Personal Income	$1,560	$1,558	-$2.3	-0.2%
Employment (thousands)	17,100	17,099	-1	-0.01%

d) Conclusion

Total annual direct costs associated with the proposed off-road equipment regulation are estimated to be approximately $568 million in 2010. Accounting for indirect costs, the proposed regulation is expected to reduce California economic output by about

$700 million, personal income by about $2.3 billion, and employment by about 1,000 from their projected levels in 2010. In the context of the State's economy, the economic impact of the proposed regulation is minor and is not expected to impose a noticeable impact.

Staff also evaluated the impact of the proposed regulation on the construction industry. As can be seen in Figure XI-6 and Figure XI-5 below, the trends in the total value of construction and the change in the construction labor force are expected to increase over the next several years. These increases outweigh the economic impacts of the proposed regulation, both from a construction valuation perspective (which is predicted to increase by over $10 billion over the next two years) and an employment perspective (predicted to increase by almost 40,000 jobs by 2009).

Figure XI-5 - Construction Total Valuation by Year (DOF, 2007a)

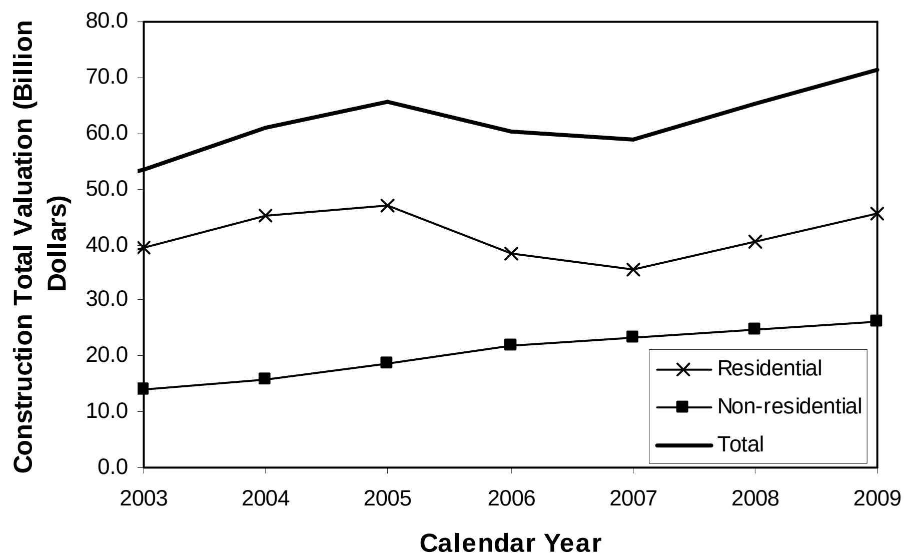
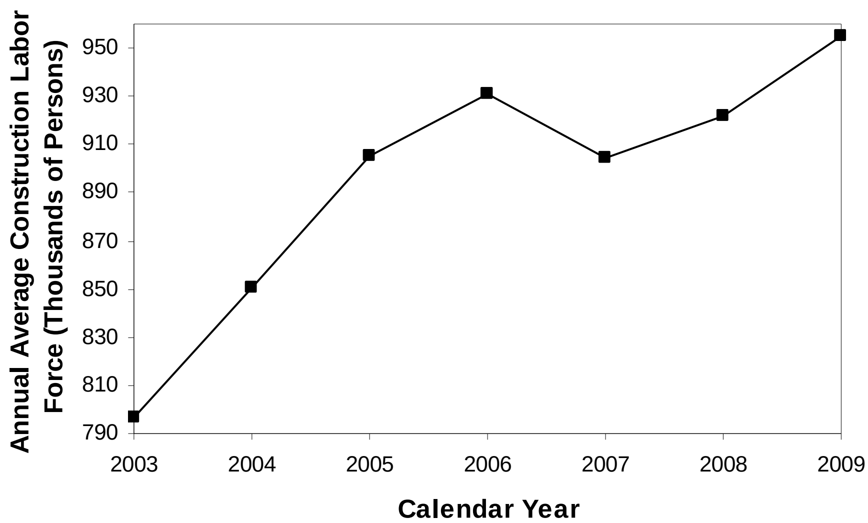


Figure XI-6 - Construction Labor Force by Year (DOF, 2007a)



The yearly costs of the regulation are significantly less as compared to the value of the construction industry, and it is expected that the regulation would not have a significant impact on the total value of construction. In addition, Figure XI-6 indicates that an increase in the construction labor force is expected to occur. Therefore, the possible jobs lost in the California economy as a result of this regulation are expected to be minimal in comparison with the job growth of the construction industry alone.

It should also be noted here that the proposed regulation would bring about significant social benefits to Californians. These benefits, which are difficult to express solely in economic terms, are not considered in this analysis, but are presented in Chapter 9.

2. *Impacts on Individual Fleets*

a) *Return on Owner's Equity (ROE) Analysis*

Overall, most affected businesses would be able to absorb the costs of the proposed regulation with no significant adverse impacts on their profitability. This finding is based on the staff's analysis of the estimated change in "return on owner's equity" (ROE) for fleets within each industry type affected by the regulation. ARB staff has traditionally used a 10 percent change in ROE as a threshold for indicating significant adverse impact from a proposed rule. Such a 10 percent change in return on equity is equivalent to a 10 percent change in profits if equity is assumed constant.

Staff made the following assumptions and data in the analysis:

- Staff used financial data for typical companies within each industry type affected to represent the financial situation for affected companies for three separate years (Dun & Bradstreet, 2003, 2004, 2005).

- For each typical company analyzed, staff assumed a fleet size by assuming that 80 percent of a companies fixed assets were vehicles affected by the rule. Other assets owned for a typical company but not affected by the regulation include facilities, on-road vehicles, portable equipment, etc.
- On average, at the start of the rule, fleets were assumed to have the same average age and horsepower size as the overall statewide fleet in the OFFROAD2007 inventory model (133 horsepower and average age of 10 years).
- Staff estimated what fraction of fleets fell within each industry type using industry type code responses from the 2005 ARB off-road equipment survey.
- Staff gathered auction data for vehicles of various ages, types, and horsepower for sale and compiled a function of vehicle price versus age for each equipment type. The median price across all equipment types was used in this analysis of typical fleets (Machinery Trader, 2006).
- Staff assumed (conservatively) that fleets would be unable to pass any of the costs on to their customers by bidding higher, etc.
- Staff conservatively did not subtract out any assumed natural turnover costs for each fleet.
- All retrofits were assumed to cost $15,000 each.

After the ROE was calculated (Equation XI-2**)** the total costs of compliance were compared to 10 percent ROE, assuming a tax rate of 41 percent.

Equation XI-2 - Return on equity (ROE) = Profit / Equity

From the ROE analysis, it was calculated that about 60 - 80 percent of fleets would be expected to be able to absorb the cost of the regulation without incurring more than a 10 percent change in ROE. The impact the regulation would have on the remaining 20 - 40 percent would depend on the ability of those fleets to raise their revenues (i.e., pass costs onto customers). Additional equations and calculations can be found in Appendix J.

b) Volunteer Fleet Analysis

In addition to the ROE analysis done on typical sample fleets, several real fleets provided their financial information for additional ROE analysis. The financial data for four fleets is shown in Table XI-16.

Table XI-16 - Results from Actual Fleet ROE Analysis

Fleet Name	Regulation Annual Cost (2006 $/yr)	Annual Revenue	Net Profit After Tax	Cost Compared to Profit	Cost Compared to Revenue
Medium Fleet A	$23,123	$7,514,193	$75,551	-24 %	0.2 %
Large Fleet A	$112,350	$3,802,281	$182,215	-40 %	3.0 %
Large Fleet B	$85,649	$77,500,000	$1,175,000	-6 %	0.1 %
Large Fleet C	$1,834,767	$41,000,000	$822,000	-132 %	2.6 %

If the costs of the regulation are compared to the profit, the decrease in profits for the volunteer fleets ranged from 6 percent to 132 percent. However, if fleets are able pass on all the costs of compliance to its customers they would need to raise their revenue by 0.1 percent to 3.0 percent while maintaining the same net profit. The ability of a fleet to pass on its costs would determine how easily the fleet can absorb the regulation costs. Because the regulation would require all fleets to comply, staff expects most of the costs of the regulation would be passed on to customers. If a fleet cannot pass on the compliance costs, in some cases, the costs of the regulation could potentially exceed its profits.

c) Impact on Performance (Surety) Bonds

A performance (surety) bond issued by an insurance (bonding) company provides guarantee to the project owner that the contractor would complete a contract. The performance bond is commonly used in construction especially in the government's contract. The bonding capacity of an individual contractor is determined by evaluating a number of factors including the contractor's, reputation, ability to meet current and future obligations, experience doing jobs of similar scale, ability to complete the work, financial strength, credit history, and other factors. Financial strength can be determined by evaluating the contractor's working capital that is the net amount of short-term liquid resources (funds) available to the contractor at any given time. Working capital represents the difference between a contractor's current assets and current liabilities.

The regulation would potentially decrease the working capital of fleets and may have an impact on the amount of performance bonds available to them. Many contractors do not request or utilize the maximum bonding amount for which they could qualify. The costs of regulation would have little or no effect on the bonding amount used by these contractors. If contractors are able to increase rates to offset the cost of the regulation, the net impact on their working capital would be negligible and the change in bonding capacity would also be negligible. Smaller contractors are more likely to be utilizing their maximum bonding capacity and may have more difficulty on passing on some of their costs to customers. However, the provisions in the regulation for small fleets and medium fleets would reduce the potential impact on these businesses and would reduce any adverse impact on their bonding amount.

H. Cost Effectiveness of the Proposed Regulation

Cost-effectiveness is expressed as control costs (dollars) per unit of pollutant emissions reduced (pounds). The cost-effectiveness for the proposed regulation is determined by dividing the total capital costs plus the annual operation and maintenance costs by the total pounds of diesel PM and NOx reduced during the years 2010 to 2030. The expected cost effectiveness of this regulation is $2.30/lb for NOx and $39.80/lb for PM. All costs are in 2006 equivalent expenditure dollars.

In considering the cost effectiveness of the regulation relative to deaths avoided, a PM cost effectiveness of $40/lb of PM is about 6 times lower than the U.S. EPA's benchmark for value of avoided death (which equates to about $248/lb). Therefore, this regulation is considered a cost-effective mechanism to reduce premature deaths that would otherwise be caused by diesel PM emissions without this regulation.

Table XI-17 below compares the estimated cost-effectiveness of the in-use off-road diesel vehicle rule to the estimated cost-effectiveness of other recently adopted ATCMs. For comparison purposes, all cost-effectiveness estimates shown in Table XI-17 attribute part of the total rule cost to PM reductions and part to NOx or HC+NOx reductions. Rules are ranked from lowest $/lb PM cost to highest.

Table XI-17 - Comparison of the Average Cost-Effectiveness of the Proposed Regulation to Average Cost Effectiveness of Recently Adopted Air Toxic Control Measures

Rule	2006 $/lb NOx Cost-effectiveness	2006 $/lb PM Cost-effectiveness	Source of Estimate
Stationary Compression Ignition Engine ATCM	0.92/lb HC+NOx	$7.70/lb PM	(ARB, 2003b)
Portable Engine ATCM	<$2/lb NOx	$8-10/lb PM	(ARB, 2004)
Cargo Handling ATCM	$1/lb NOx	$21/lb diesel PM	(ARB, 2005a)
Solid Waste Collection Vehicle ATCM	1.79/lb HC+NOx	$32/lb PM	(ARB, 2003a)
In-Use Off-Road Diesel Vehicle Rule	$2.1 - 2.5/lb NOx	$37 - 43/lb PM	See Chapter 11 and Chapter 9
Public Fleets Rule	$10.92/lb HC+NOx	$159.95/lb PM	(ARB, 2005b)

As Table XI-17 shows, the cost-effectiveness of the rule is within the range of measures previously adopted by ARB.

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XII. REGULATION DEVELOPMENT TOPICS

This chapter describes topics that were encountered in the development of the proposed regulation and explains how they are addressed. The following topics are discussed:

- Why ARB staff is proposing special provisions for low-use equipment and why the low-use threshold is set at 100 hours per year;
- Why ARB staff is proposing stricter requirements for the largest fleets and less strict requirements for smaller fleets, and how the thresholds for the large and small fleet definitions were set;
- Why the fleet average calculation is structured as proposed;
- Why the proposed limit on unnecessary idling is set at five minutes;
- What incentive program funding may be available to help fleets pay for compliance with the rule and what restrictions would apply to use of this funding;
- What the rule would mean for sensitive sites and receptors and additional actions local governments and others could take to further address these receptors and sites;
- How the rule would be enforced; and
- Why the proposed regulation does not result in a regulatory taking.

A. Low-use threshold

A vehicle that operates very few hours each year emits less air pollutants than an identical vehicle that operates more each year. It thus poses less of a risk to public health than a similar more heavily used vehicle. Because it costs the same to retrofit or replace a relatively low-use vehicle as it would for a higher-use vehicle, it is less cost-effective to control emissions from low-use vehicles than from higher use vehicles. Generally, low-use vehicles also generate less revenue and so generate less money to pay for controls. To address this, the proposed rule includes an exemption for low-use vehicles.

Vehicles that operate less than 100 hours per year are exempt from all but the labeling and recordkeeping portions of the proposed rule. Staff evaluated various possible thresholds for the low-use definition and chose 100 hours per year as the best threshold for making the rule as cost-effective as possible without foregoing appreciable emission reductions. Table XII-1 shows the population, emissions, and cost-effectiveness of controlling vehicles at various annual hours of operation. By comparison, the low-use threshold in ARB's large spark-ignition engine fleet rule is 251 hours per year, but emissions from low-use equipment must be addressed by January 1, 2011 (Title 13, Section 2775(d)(1)). The low-use threshold in ARB's portable equipment air toxic control measure is 80 hours per year. Low-use portable engines must be controlled to Tier 4 levels or retrofit with a Level 3 device by January 1, 2020 (Title 17, section 93116.3(b)(3)).

If the threshold for the low-use definition were set very high (such as at 200 hours per year), the rule would leave many vehicles uncontrolled and would achieve far less emission reductions. As shown in Table XII-1, based on survey data from the 2005 ARB off-road equipment survey, over 20 percent of affected vehicles operate less than 200 hours per year (ARB, 2006). If the low-use threshold were set at 200 hours per year, in 2010, about 7 percent of the potential emission reductions would be foregone. By 2020, the low-use vehicles would represent an even greater portion of the emissions from affected vehicles (because the higher use vehicles would be controlled by then) and an estimated 9 to 11 percent of potential emission reductions would be foregone.

If the threshold for the low-use definition were set very low (such as at 50 hours per year), the rule would achieve more emission reductions but would be less cost-effective. As shown in Table XII-1, the cost-effectiveness of controlling an engine that operates 50 hours per year is $411/lb PM and $65/lb NOx, which exceeds the typical cost-effectiveness of previously adopted rules and the cost-effectiveness funding threshold of incentive funding programs like the Moyer program.

Table XII-1 - Vehicle Population and Emissions and Cost-effectiveness of Control for Various Annual Hours of Operation[30]

Annual Hours of Operation	Vehicle Population	NOx and PM Emissions Contribution		Cost-Effectiveness ($/lb)	
		2010	2020	PM	NOx
Less than 50 hrs/yr	5.0%	0%	1%	$411	$65
Less than 100 hrs/yr	10.5%	2%	2-3%	$205	$32
Less than 150 hrs/yr	16.1%	4%	5-6%	$137	$22
Less than 200 hrs/yr	21.6%	7%	9-11%	$103	$16

B. Small and Large Fleet Thresholds

From the ARB 2005 off-road equipment survey, staff learned that the majority of fleets are small fleets (i.e., fleets with very few vehicles), but that the majority of affected vehicles were owned by large fleets (i.e., fleets with many vehicles) (ARB, 2006). Table XII-2 shows the total horsepower, number of vehicles, and number of fleets with less than or equal to 1,500 hp, 1,501-5,000 hp, and greater than 5,000 hp. As Table XII-2shows, over half the fleets have 1,500 or less horsepower, but such small fleets have less than five percent of the total hp of

30 Assumes low-use vehicles are ten years older on average than typical vehicles. Assumes typical vehicles operate about 1,000 hours per year on average.

affected vehicles. Conversely, only five percent of fleets have total maximum power over 5,000 hp, but these very large fleets have over two thirds of the total hp of affected vehicles.

Table XII-2 - Total Horsepower, Total Vehicles, and Number of Fleets by Fleet Size

Size Category	Fleet Size (hp)	Survey Results		
		Total hp	Equipment Count	Fleet Count
Large	>5,000	81%	72%	13%
Medium	1,501-5,000	12%	16%	16%
Small	<=1,500	6%	12%	71%

ARB staff is proposing earlier compliance dates for larger fleets for the following reasons. First, ARB staff recognizes that the largest fleets would have more opportunity to select which vehicles would cost the least to control, generally have more financial resources, and would likely be better situated to understand how to comply rapidly with the rule. The largest fleets are large companies or government agencies that are likely to have environmental specialists on staff. Many of the smallest fleets on the contrary may be one or two-person operations, for whom learning about and understanding the rule may be a bigger challenge. Second, larger fleets are more likely to be able to absorb the cost of the regulation, especially compared to some of the smallest fleets who may be relatively economically challenged. The largest fleets have economies of scale and access to financing that the smaller companies cannot duplicate. Finally, educating a smaller number of stakeholders and enforcing the rule for the relatively few largest fleets would provide substantial air quality benefits and allow more time to address enforcement issues and to expand education and enforcement to the very numerous smaller fleets.

Staff recognize that providing more time to comply and less stringent compliance requirements (ie. no turnover for NOx) for the smallest fleets would forego some emission reductions. To minimize the loss in emission reductions, the 1,500 hp cutoff for small fleets was chosen such that it represents less than five percent of the total statewide horsepower, and thus less than five percent of the total potential NOx emission benefits would not be realized.

Staff also recognizes that small businesses face a special challenge in learning about, understanding, and paying for compliance with the rule. Larger businesses who, because of the nature of their business, own only a few pieces of off-road equipment and whose total hp is also 1,500 hp or less do not necessarily face this same challenge. For example, a large warehousing company with a few diesel forklifts does not face the same compliance challenge as a small construction contractor with a compactor, dozer, and two small loaders. The cost of compliance for the warehousing company is likely to be a much smaller fraction of profits and revenues. Staff is thus not proposing to extend the special provisions and later compliance dates crafted for small fleets to large businesses who own 1,500 horsepower or less.

C. Fleet Average Calculation

As discussed in Chapter 7, the proposed regulation would include a fleet average calculation. Each fleet would calculate its PM and NOx indices and then compare them to its fleet average target to see if it meets the fleet average requirements. The form of the equation to calculate PM and NOx indices is shown below.

Equation XII-1: $$\frac{\sum_{i=1}^{n} MaxHp_i \times EmissionFactor_i}{\sum_{i=1}^{n} MaxHp_i}$$

The proposed regulation provides a table of emission factors for NOx and PM. In the tables, the emission factor for each engine is based on the new engine standard to which the engine is certified. For engines that are not certified to a new engine standard (i.e., Tier 0 engines and Tier 1 engines between 50 and 174 hp, for which there is no PM standard), the proposed regulation provides surrogate emission factors. For engines 25 to 49 horsepower, the surrogate emission factors were calculated with the new engine (zero-hour) emissions factors, deteriorated up to the emissions they would have after 5,000 hours of operation per the OFFROAD2007 model. For engines greater than or equal to 50 horsepower, the same methodology utilizing 8,000 hours of operation was used. The hours of operation are consistent with the durability requirements identified in the engine emissions standards (title 13, CCR, sections 2423(b)(8) and 2421(a)(59)) for regulated off-road engines. A compliance margin of 20 percent was added, consistent with the compliance margin calculated by the OFFROAD model for regulated engines.

The first subsection below describes why ARB staff is proposing basing the emission factor on the certification level rather than the certification standard. The second subsection describes why ARB staff opted not to include load factor in the calculation of PM and NOx indices.

1. Certification Standard Versus Certification Level

In the calculation, for engines that are certified to a PM and NOx emission standard, the PM or NOx standard is used as the emission factor. Some stakeholders asked that the certification level (cert level) rather than the certification standard be used as the emission factor for the fleet average. The certification standard is preferable and was chosen for the reasons described below.

The certification level shown on certification executive orders represents a summary of actual test data of one engine. Engine manufacturers do not guarantee that cert level has any relation to an in-use engine's emissions. The standard, on the other hand, represents the enforceable limit under which engine manufacturers guarantee their engine would remain for their durability periods. ARB staff opted to use the certification standard as the emission factor in the fleet average rather than the cert level because the certification standard is the enforceable limit. Use of the certification standard is also consistent with how the fleet average in ARB's large spark ignition rule is structured (title 13, CCR section 2775).

If staff had opted to include the certification level rather than the certification standard in the calculation of the PM and NOx indexes, the fleet average targets would have been accordingly adjusted. For example, if cert levels were generally 30 percent lower than certification standards, then the fleet average targets would all have been reduced by 30 percent in order to achieve the same emission reductions. In other words, using the certification level in lieu of the certification standard in the fleet average would not affect the overall stringency of the regulation (i.e., the actions of fleets required to meet the targets and to result in actual emissions reductions).

2. Load Factor

The PM and NOx indices are tracking tools meant to estimate how high a fleet's PM and NOx emissions are relative to other fleets with a similar mix of engine sizes. The PM and NOx indices are not intended to provide an accurate estimate of the actual mass of PM or NOx emissions emitted from any fleet. Like the fleet averages used in ARB's portable equipment air toxic control measure and large spark ignition rule, the proposed fleet average for the in-use off-road diesel vehicle rule does not include load factor (the ratio of engine power output during typical operation to the maximum rated horsepower). The proposed regulation does not require hours of use to be used in the fleet average calculation, but gives fleets the option of doing so if they have adequate records.

Although including load factor would make the indices a closer approximation to actual emissions, ARB staff opted not to include the load factor in the indices for the following reasons:

- It avoids added complexity, recordkeeping, and reporting.
- Excluding the load factor would avoid having to spend time determining and debating the appropriate load factor for each piece of equipment and resulting enforcement actions because of differences in opinion.
- Load factors vary by vehicle category and would vary depending on the attachment on the vehicle at the time. For example, a tractor might be used with one attachment for a while and have one load factor, and when the attachment is switched, the load factor would change.
- The overall goal of the rule is to have <u>all</u> equipment controlled, when it is feasible and cost-effective to do so.

Further, if ARB staff had opted to include load factor in the fleet average calculations, the fleet average targets would have been adjusted to include it. For example, if staff had assumed an average load factor of 0.5, then the fleet average targets in the proposed rule would also have been multiplied by 0.5. For example, the NOx fleet average target for 300-599 hp equipment in year 2013 would have been proposed at 2.4 rather than 4.7. In other words, whether load factor is included in the fleet average would not affect the overall stringency of the rule (i.e., the actions of fleets required to meet the targets). Including load factor would only change compliance with the rule by allowing fleets to get more credit by reducing emissions from engines with higher load factor versus those with lower load factor.

ARB's OFFROAD2007 model, which was used to estimate baseline emissions and the emission benefits of the off-road equipment rule, incorporates load factor, hours of use, vehicle population, growth rates, emissions factors, deterioration rates, and a variety of other factors to estimate actual emissions. Although most of these factors are not included in the fleet average calculation, they are taken into account in the estimates of PM and NOx baseline emissions and emissions benefits elsewhere in this Technical Support Document.

D. Five-Minute Idling Limit

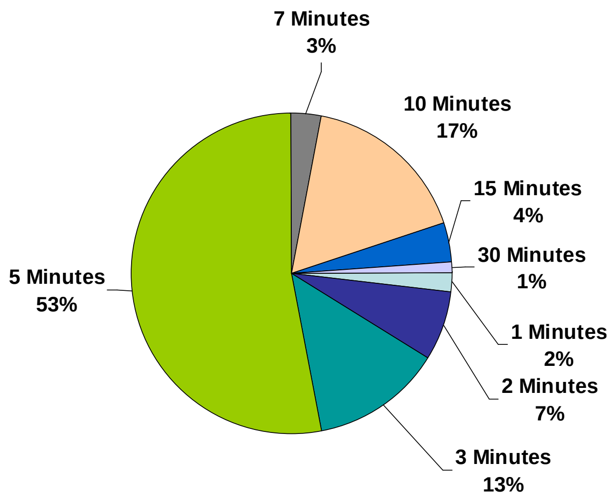
The proposed regulation would include an idling limit to reduce unnecessary emissions. Side benefits of the idling limit would include saving money and fuel when unnecessary idling is eliminated. Staff did not estimate cost savings from reduced idling.

Staff set the time limit for unnecessary idling in the proposed rule at 5 minutes because it was consistent with the commercial vehicle idling and school bus idling rules, as well as with the idle time limit for the majority of fleets that already have an idling policy. The commercial vehicle idling rule in title 13, CCR section 2485 and the school bus idling rule in title 13, CCR section 2480 both limit idling to 5 minutes.

Staff confirmed that the emissions from 5 minutes of idling were greater than the additional start emissions expected when a vehicle that shuts down to limit idling emissions is restart. That is, eliminating idling of 5 minutes or longer would be expected to reduce emissions.

ARB's 2005 off-road equipment survey asked respondents whether they already had a policy limiting off-road vehicle idling, and what their idle time limit was (ARB, 2006). Out of 432 survey responses, 51 percent indicated they have an idling limit policy. Most already have a policy to limiting idling to 5 minutes or less. 126 surveys received provided a numeric idle time limit. Figure XII-1 below shows the distribution of idle time limit responses received. Responses ranged from 1 minute to 30 minutes, and three quarters of the respondent indicated they restrict idling to less than or equal to 5 minutes.

Figure XII-1 - Idle Time Limits in Fleets' Idling Policies (2005 ARB Off-road Equipment Survey)



E. Availability of incentive funding

Incentive programs have the ability to prompt emissions benefits early or beyond those required by regulations. California has the largest clean air incentive program in the nation, the Carl Moyer Program, with up to $140 million available each year through State and local funds.

In addition to the Carl Moyer Program, ARB is in the process of rewarding $25 million to public agencies for the purchase of low-polluting construction equipment (ARB, 2007). This money was part of a one-time allocation from the 2006-2007 State budget. It would help some public agencies begin to clean up their fleets in advance of the proposed rule. Funding is available for purchase of the cleanest available construction equipment for the horsepower category, repower with the cleanest available engine for the horsepower category, or installation of a Level 3 retrofit.

Even so, this level of funding is far from sufficient to pay for all the reductions needed to provide clean air. Reductions required by regulations, and funded by owners of the affected equipment, must continue to provide the majority of emission reductions. Incentive programs, such as the Carl Moyer Program, fund the incremental cost of cleaner-than-required engines, equipment, and other sources of pollution providing early or extra emission reductions. The Carl Moyer Program emission reductions are credited in California's State Implementation

Plan and must be real, surplus to regulatory requirements, quantifiable, and enforceable.

The Carl Moyer Program is administered by local air districts. The funding is distributed according to a formula in state law that considers population and the severity of the air pollution problem. Some air districts choose not to participate in the program. Statewide, the Carl Moyer Program has been oversubscribed every year, and this continues to be the case today. Eligible off-road projects must compete with on-road, agricultural pump, marine, locomotive, and other projects for funding. Many of these source categories are now regulated and also have short windows remaining for funding.

In the past 9 years the Carl Moyer Program has provided significant funding for off-road equipment. The relative funding for off-road equipment has been steadily increasing, with off-road equipment projected to receive about 50 percent of Carl Moyer Program funds from the fiscal year 2004-2005 allocation. Off-road projects in the Carl Moyer Program generally consist of engine replacements with participants on average receiving a grant of $36,600, or about 70 percent of funding for the engine replacement. Although new purchases have been eligible for incentives, purchase of new low-emission equipment has not been feasible since only engines that have been certified to the voluntary “Blue-Sky Series” low-emitting engine standards are eligible for grants and none have been certified. Retrofit has also been eligible for grants, but, until very recently, ARB verified retrofits have not been available for most off-road equipment. Retrofits are currently required on all Carl Moyer Program funded repower projects if available, feasible, and cost-effective.

The Carl Moyer Program has a minimum three year project life which means that incentive funds can not be used to pay for equipment that is less than three years from its compliance deadline. Therefore fleets with earlier compliance dates would have limited opportunity for funding. Fleets with extended compliance dates, such as small fleets, would have greater funding opportunities.

As the proposed regulation is structured, the majority of fleets would start out complying with the BACT requirements and, as they turnover and retrofit their equipment, would eventually meet and comply with the fleet average targets in later years. In determining eligibility for Carl Moyer Program funding, it would be assumed that all fleets are complying on the proposed BACT path. The proposed BACT path requires 8 percent turnover of the total horsepower in the fleet per year until 2015 (10 percent thereafter) and 20 percent retrofit of the total horsepower in the fleet per year to meet the NOx and PM requirements, respectively. Since these proposed BACT requirements involve retrofit and/or turnover of a percentage of horsepower in the whole fleet, the entire fleet must be considered when determining whether funding is available and how much is available.

The example in Table XII-3 illustrates how eligibility for Carl Moyer funding would be determined. Consider a large fleet that requests funding for equipment that would be installed and in operation by February 28, 2008. The fleet is unable to receive Carl Moyer Program funds for the equipment that would have to be in compliance with the rule by March 1, 2011 (shaded area), but would be able to receive funds for equipment whose compliance dates are further away (unshaded area).

Table XII-3 - Carl Moyer Program Funding Example

Compliance Date (March 1)	Turnover (% of total hp)	Retrofit (% of total HP)
2010	8%	20%
2011	8%	20%
2012	8%	20%
2013	8%	20%
2014	8%	20%
2015	8%	--
2016	10%	--
2017	10%	--
2018	10%	--
2019	10%	--
2020	10%	--

As such, in order for a large fleet to receive funding for equipment that would be installed and in operation by February 28, 2008, a fleet owner would need to turnover 16 percent (the 8 percent required by March 1, 2010, and the 8 percent required by March 1, 2011) by February 28, 2008 in order to be eligible for incentive funding for 84 percent of the fleet. The fleet would also have to retrofit 40 percent (the 20 percent required by March 1, 2010, and the 20 percent required by March 1, 2011) by February 28, 2008 to be eligible for incentive funding for retrofitting the remaining 60 percent of the fleet.

With the adoption of the proposed regulation, it is unlikely that most projects for large fleets would qualify for Carl Moyer Program funding because of the early compliance date and high initial investment in order to take advantage of the funding.

As is the case with all ARB regulations, the Carl Moyer Program would not pay for compliance extensions or for equipment that has been granted a compliance extension, such as the six year exemption from turnover given to retrofitted equipment.

1. Small Fleets

The first compliance dates for fleets that qualify for the small fleet provision of the regulation are further out in the future so greater opportunities for funding exist. Small fleets may qualify for incentive funds in two ways:

1. For small fleets, compliance with the PM requirement begins on March 1, 2015 and would require retrofit of up to 20 percent per year of the total horsepower in the fleet. Small fleets would be eligible for incentive funds to pay for the full cost of the retrofit that are installed and in operation by February 28, 2012 subject to the cost-effectiveness cap. After March 1, 2012, fleets could receive incentive funds in a manner similar to the example given for large fleets.
2. Small fleets would have no NOx requirements in the proposed regulation; therefore, would not be required to turn over their equipment. As such, funding for NOx and ROG reductions would always be eligible for incentive funds. This means that fleet owners could apply for Carl Moyer Program funds to repower their equipment and would be eligible for grants based only on NOx and ROG reductions. Since the Carl Moyer Program requires retrofit on all repower projects, up until February 28, 2012 both the repower and the retrofit are eligible for funding. After February 28, 2012, the retrofit would still be required but must be paid for by the fleet owner.

2. Medium Fleets

The first compliance date for fleets that qualify for the medium fleet provision of the regulation is March 1, 2013, so some opportunities for funding exist. Medium fleets can apply for Carl Moyer Program funding for projects that would be installed and in operation by February 28, 2010. For projects that would be installed and in operation after March 1, 2010, fleets could receive incentive funds in a manner similar to the example given for large fleets.

3. Fleets exempt from the NOx requirements

Captive fleets in federal ozone attainment areas are only subject to the PM requirements of the regulation regardless of fleet size and are therefore only required to retrofit their equipment, not to turnover the equipment. As such, funding for NOx reductions would always be eligible for incentive funds. This means that fleet owners could apply for Carl Moyer Program funds to repower their equipment and would be eligible for grants based only on NOx and ROG reductions. The retrofit would still be required but must be paid for by the fleet owner.

F. Site-specific or Sensitive Receptor Requirements

Sensitive receptors, including such individuals as children, the elderly, and people whose health is already compromised, are particularly susceptible to pollution from diesel vehicles (ARB, 2005a). Staff considered including special requirements in the regulation for off-road vehicles used near sites where such sensitive receptors are likely to be present such as at schools and hospitals, but ultimately decided a fleet-based regulation that cleans up the entire fleet would be preferable for the following reasons:

- As previously discussed, the long term risk from any one construction project is expected to be low and is already subject to an environmental review process. For large public projects and for those that require any kind of public permitting or approval, the California Environmental Quality Act (CEQA) already requires a process by which risks from individual projects are evaluated and mitigated. This provides for project specific mitigation that takes into account local land use (such as how close is the nearest school, day care center, hospital, etc).
- The transient nature of off-road diesel vehicle use makes it more difficult to impose sensitive receptor provisions. Although several of ARB's existing air toxic control measures, such as that for emergency standby diesel generators, contain special requirements for sensitive receptors, the transient nature of off-road diesel vehicles (often used for just a short time and then moved to another location) makes it much more difficult to incorporate special provisions for sensitive receptors into a statewide rule like that proposed.
- Sensitive receptor provisions would add complexity and make compliance and enforcement much more challenging.

The proposed regulation would require the gradual cleaning up of the statewide fleet of in-use off-road diesel vehicles. As the fleet is cleaned up, and especially as exhaust retrofits that capture toxic diesel PM emissions begin to be installed, the risk to sensitive receptors would decrease, along with the risk to all breathers in California. As discussed below, local agencies and others may wish to take action to further reduce the risk posed by large construction projects.

For large construction projects, local governments, communities, and developers may wish to consider additional requirements to limit the public's exposure to toxic emissions from diesel vehicles. Diesel PM is a carcinogen, and – as such – has no safe threshold below which there is no risk. Local agencies could choose to impose in-use operational controls, such as hours of use restrictions, or could possibly impose additional requirements through the CEQA process for projects that cause significant environmental impacts or through public project contract requirements.

Such requirements could be applied to all projects within a certain distance of sensitive sites, or could be limited only to those of a certain duration or that disturb greater than a certain area of soil. The following requirements could be adopted on a project specific basis as mitigation measures as part of the CEQA or National Environmental Policy Act (NEPA) process or built into contract requirements for public projects:

- Limit construction vehicles used near such sensitive sites to vehicles cleaner than a certain tier (Tier 2 or cleaner, for example) and require that all such vehicles be retrofit with the highest level verified diesel emission control system.
- Limit construction to times when sensitive receptors are not present. For example, projects within 500 feet of a school could be limited to non-school hours.
- At a minimum, developers and public agencies that sponsor large construction projects should ensure that any contractors they hire have reported their vehicles to ARB and are in compliance with the proposed regulation.

Local governments could also consider the risk from off-road diesel vehicles when considering approval for construction near where sensitive receptors are likely to be present (i.e., schools, hospitals, housing). Conversely, land use planners may wish to consider the location of existing landfills, recycling centers, and other facilities that require the use of diesel vehicles when siting homes and schools and hospitals. Several land use handbooks exist to help guide local land use decisions – for example, the *Air Quality and Land Use Handbook* (ARB, 2005), and the *Guidance Document for Addressing Air Quality Issues in General Plans and Local Planning* (South Coast Air Quality Management District, 2004).

G. Enforcement

The critical elements to the successful enforcement of the proposed regulation would be the annual reporting and the equipment identification number (EIN). The reporting would allow ARB staff to initially determine whether fleets have either met the fleet average targets or complied with the BACT requirements. Fleets would report each vehicle, its equipment identification number (EIN), its engine data, its model year, as well as any actions taken to comply. For vehicles claimed as low-use, owners would report the hour-meter readings.

Fleets that report noncompliance with the fleet average/BACT requirements would automatically be subject to enforcement action, as would fleets that do not report at all. Fleets that submit questionable annual reports would also be subject to follow-up inspections and possible enforcement action. An annual report that appears appropriate would not preclude its fleet from an ARB audit.

Each vehicle would have its EIN displayed prominently on the side of the vehicle. When ARB inspectors conduct an equipment field audit, they would be able to link the EIN to whatever action was claimed for that vehicle. They would be able to tell if the vehicle does not have the engine claimed, or is not outfitted with the retrofits claimed or whether the retrofits have been correctly installed. Even though in most cases inspectors may not be able to view an owner’s entire fleet because it would be dispersed in various locations, inspectors would be able to verify compliance for whatever vehicles they encounter. If inspectors find vehicles without the retrofits that were reported or with dirtier engines that were reported, fleets would be subject to enforcement action.

If inspectors find vehicles that are subject to the rule that are not labeled with an EIN, then that would be an immediate indication of noncompliance. Vehicles that have come in from out of state would need documentation showing their dates of entry. If a vehicle has been delivered into California beyond 30 days of its date of entry without reporting, enforcement action would be taken. For vehicles claimed as low-use vehicles, a log of hour meter readings upon entry and exit from the state would be required.

ARB inspectors may use a variety of opportunities to find and inspect off-road vehicles. For example, they may conduct audits of fleets at facilities including but not limited to landfills, mines, and recycling facilities. They may also inspect large construction sites. A search of construction permits from the State Water Resources Control Board may provide a way to target inspectors toward larger construction sites.

They may also inspect off-road vehicles they encounter being transported by truck. Finally, inspections may be triggered if ARB receives reports from the public that indicate that certain equipment has been observed with smoking exhaust or that a fleet is not in compliance with the rule.

Enforcement of the idling portion of the rule would be conducted similarly to enforcement of ARB's commercial vehicle and school bus idling rules. Complaints from the public via calls to the 1-800-END-SMOG toll-free line or on-line reporting trigger inspections or further enforcement action.

Staff would provide public access to the names of the companies who have reported. While details of each fleet and its compliance strategy would not be made public, the public would be able to search the reporting database to confirm whether companies they are considering hiring have reported and submitted the required certifications of compliance. This would allow developers and others wishing to hire construction firms to ensure they hire only fleets that have reported their data to ARB, and would allow companies to check whether their competitors have reported and certified compliance. If a developer is considering an out-of-state off-road equipment firm, it should notify that firm to report its equipment to the state prior to implementation of the project. Because the rule would impose significant costs, to ensure a level playing field, it would be important to ensure that firms who are competing against one another are all complying. Certain business and professions codes that protect fair competition may be used against a non-complying firm.

ARB would have the responsibility for enforcing the proposed rule. From time to time, local air district staff may encounter vehicles that they believe are not in compliance with the proposed regulation. In addition, district inspectors may observe or be told by the public of situations where vehicles are exceeding the proposed idle limits. In these situations, the district staff could notify ARB staff so that ARB staff can take appropriate enforcement action. ARB plans to request additional staff resources to aid in outreach, education, and enforcement of the proposed regulation if adopted.

H. Regulatory Takings

Some stakeholders have commented during the course of this regulation's development that the proposed regulation would result in a regulatory taking. Specifically, they argue that the proposed regulations force replacement of older, dirtier engines, and would significantly devalue the market for the engines and vehicles equipped with such engines. ARB staff does not agree that the regulation would result in an unconstitutional takings. The "Takings Clause" of the Fifth Amendment to the United States Constitution provides that the federal government shall not take private property for public use, without just compensation.[31] The prohibition was extended to the states by the Fourteenth Amendment.[32]

Generally, in real property regulatory takings claims, courts have found a compensable taking if a regulation does not substantially advance legitimate state interests or has permanently deprived an owner of "all economically beneficial or productive use" of the land. (*Lucas v. South Carolina Coastal Council (1992)* 505 U.S. 1003, 1015; *Tahoe-Sierra Preservation Council, Inc. v. Tahoe Regional Planning Agency* (2002) 535 U.S. 302) In determining whether a state may avoid compensation when it has used its police powers for public health and welfare purposes, and the action has resulted in depriving an owner of all beneficial or productive use of his land, the courts have looked to see if the proscriptions of the regulation were, in fact, covered by preexisting implied limitations on the property owner's title. (*Lucas v. South Carolina Coastal Council*, *supra,* 505 U.S. at 1027.) In *Lucas*, the Court acknowledged that where such implied limitations exist, "the property owner necessarily expects the uses of his property to be restricted, from time to time, by various measures newly enacted by the State in legitimate exercise of its police powers." (*Id.)*

[31] The Fifth Amendment provides in full:

> No person shall be held to answer for a capital, or otherwise infamous crime, unless on a presentment or indictment of a Grand Jury, except in cases arising in the land or naval forces, or in the Militia, when in actual service in time of War or public danger; nor shall any person be subject for the same offence to be twice put in jeopardy of life or limb; nor shall be compelled in any criminal case to be a witness against himself, nor be deprived of life, liberty, or property, without due process of law; nor shall private property be taken for public use, without just compensation.

[32] The Fourteenth Amendement provides in relevant part that "[no State shall] deprive any person of life, liberty, or property, without due process of law; nor deny to any person within its jurisdiction the equal protection of the laws."

Of significance to the instant proposed regulation, the Court went on to clarify that implied limitations on ownership rights almost always exist with regard to the commercial value of personal property. The Court stated:

> [I]n the case of personal property, by reason of the State's traditionally high degree of control over commercial dealings, [the personal property owner] ought to be aware of the possibility that new regulation might even render his property economically worthless. (*Id.*, at 1027-1028.)

In line with the Supreme Courts decisions with regulatory takings, the proposed regulation cannot be considered as unconstitutional. First, the regulation would not deprive the stakeholder of all beneficial value of the regulated engines and vehicles. Even those engines and vehicles that must be retired under the proposed regulation would continue to retain fair market value in domestic and international markets outside of California. Second, consistent with *Lucas,* even in the unlikely event the regulated engines and vehicles lost all of their beneficial value, ARB is exercising its vested police power authority to regulate in-use off-road fleets. Over the past 40 years, ARB has adopted a panoply of air quality regulations affecting nearly every vehicular source category. Given the extreme air quality problems confronting most areas of the state, owners of in-use off-road vehicles should be well aware that regulation of their fleets was likely to occur, especially given the high level of emissions associated with the operation of such vehicles.

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