SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Feasibility Study for Controlling Emissions from Yard Tractors

Draft White Paper

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Preface

This draft White Paper includes the South Coast Air Quality Management District (AQMD) staff's feasibility analysis for reducing emissions from yard tractors which entails background information, a technology assessment with preliminary cost-effectiveness calculations, an evaluation of possible regulatory approaches, and recommendations for future rule development.

As part of the 2003 AQMP adoption Resolution, the Governing Board committed the AQMD to conduct a number of feasibility studies for reducing emissions from several mobile source categories in order to expedite the implementation of long-term measures. If measures were determined to be feasible technically and legally, staff would proceed with rule development. This White Paper satisfies the AQMP commitment for conducting the feasibility study of yard tractors. In addition, this analysis is consistent with the requirement to evaluate yard tractors for possible controls as part of the enhancement to the AQMD's Environmental Justice program.

Staff presented the concepts set forth in this White Paper to AQMD's Mobile Source Committee on February 27, 2004, whose members concurred with staff's recommendation to proceed with rule development commensurate with AQMD's authority. Accordingly, staff will initiate the rule development process by releasing the draft White Paper, establishing a stakeholders working group, and developing the specific rule requirements.

EXECUTIVE SUMMARY

As part of the commitments under the 2003 Air Quality Management Plan (AQMP) as well as implementation of the enhancements to the South Coast Air Quality Management District's (AQMD) Environmental Justice Program, AQMD staff conducted a feasibility study for reducing emissions from diesel-powered yard tractors.

Diesel powered yard tractors, also known as yard hostlers or yard spotters, are truck tractors which are used to transfer semi-truck or tractor-trailer containers in and around storage, transfer, or distribution yards or areas (e.g., port terminals, locomotive switching yards, and distribution centers). This White Paper provides the results of the feasibility study including background information, a technology assessment, an evaluation of possible regulatory approaches, and recommendations for subsequent rule development. The potential regulatory approaches for this source may also be applicable to other off-road intermodal equipment.

The results of the feasibility study indicate that there has been considerable public and private effort to develop emission control strategies for diesel engines applicable to yard tractors, including retrofit controls, alternative diesel fuels, and integrated hardware systems with alternative diesel fuel. Proven emission control technologies that are commercially available and verified by the California Air Resources Board (CARB) for off-road applications (e.g. yard tractors) are diesel oxidation catalyst/crankcase emission control systems (approximately 25% reduction in PM10 emissions) and emulsified diesel fuel (approximately 60% reduction in PM10 and 15% reduction in NOx emissions). Other viable control strategies for controlling emissions from yard tractors include alternative fueled (i.e., natural gas, liquefied propane gas) vehicles as well as vehicles which are powered by engines certified to on-road engine standards, rather than the off-road engines that typically power yard tractors.

Based on the feasibility analysis, the most cost-effective method of reducing emissions from existing yard tractors is the use of yard tractors with on-road certified engines. The cost-effectiveness of using on-road certified engines in yard tractors ranges from approximately $200 - $3,100 per ton of NOx+PM reduced depending on which models of off-road yard tractors (i.e., uncontrolled, Tier 1, Tier 2, or Tier 3) are replaced with yard tractors powered by on-road certified engines.

A number of possible regulatory approaches were also investigated by AQMD staff for yard tractors including: Fleet Rule Approach; Indirect Source Approach; Retrofit Approach; and Air Toxics Reduction Approach. The four approaches were evaluated based on the AQMD's extent of existing legal authority over yard tractors. Based on the analysis, staff recommends pursuing an indirect source rule approach for reducing emissions from yard tractors. Under this approach, staff would develop an indirect source rule that would establish use restrictions (e.g., hours of operation, fuel consumption) for yard tractors operated at ports. As part of rule development and in lieu of use restrictions, staff would also consider including alternative compliance options at the choice of equipment operators that would result in equivalent emission reduction benefits. These alternative compliance options could include strategies such as a fleet average emission rate, purchase/retirement requirements, operational improvements, alternative fuels option, or a mitigation fee. Following the release of this White Paper, staff will proceed with rule development in conjunction with all stakeholders. The next phase of rulemaking will be developed for yard tractors operated at rail yards and distribution centers.

INTRODUCTION

Yard tractors, also known as yard hostlers or yard spotters, are truck tractors (typically ranging from approximately 150 to 250 horsepower) which are used to transfer semi-truck or tractor-trailer containers in and around storage, transfer, or distribution yards or areas (e.g., port terminals, locomotive switching yards, and distribution centers). This White Paper is intended to provide a feasibility study for controlling emissions from diesel powered yard tractors and consists of an emissions inventory assessment, control technologies evaluation, cost-effectiveness analysis, and an evaluation of potential regulatory approaches and specific recommendations for future actions. The impetus for this study is based on a number of AQMD Governing Board actions, including those related to the AQMD's Air Toxics Control Plan, the AQMD's Environmental Justice program, and the 2003 AQMP. These programs are briefly summarized below and described in greater detail later in this chapter.

In August 1998, CARB identified particulate matter from diesel engine exhaust as a toxic air contaminant (TAC) (http://www.arb.ca.gov/regact/diesltac/diesltac.htm). In 1999, the AQMD conducted Multiple Air Toxics Exposure Study (MATES) II which identified mobile sources, particularly diesel exhaust, as the overwhelming contributor to local air toxic risk levels (http://www.aqmd.gov/matesiidf/matestoc.htm)[1]. The findings showed that the cancer risk from toxic air pollution averages about 1,400 in a million in the region with 71 percent of this cancer risk attributable to diesel particulate, as shown in Figure 1-1.

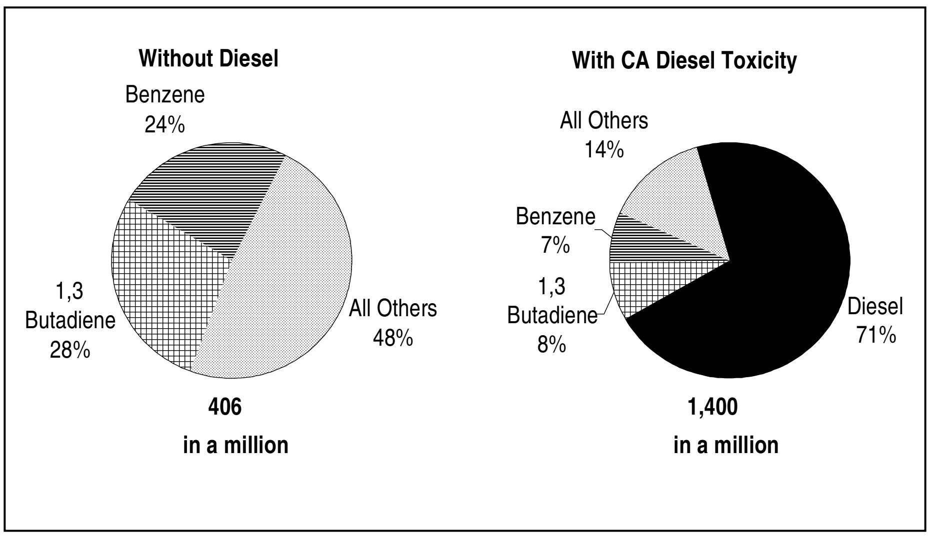

Figure 1-1
Estimated Average Basin Toxic Risk Contributions

Based on the results of the MATES II study, the AQMD Governing Board in March 2000 adopted the Air Toxic Control Plan which included a number of control strategies targeting emissions from diesel engines used in mobile sources.

[1] To further monitor and evaluate urban air toxic emissions, AQMD is currently conducting a MATES III study, which began early 2004 and will last approximately one year.

In September 2002, the AQMD Governing Board approved 23 enhancements to its Environmental Justice Program. Environmental Justice enhancement III-1 cites yard tractors as a local source of PM10 and NOx emissions that have not been subject to strict emission requirements in the past, and seeks to develop an emissions inventory and provide emission reduction opportunities from this equipment category. A second enhancement directed staff to develop a white paper on regulatory options for addressing cumulative impacts from air pollution sources. The White Paper on Potential Control Strategies to Address Cumulative Impacts From Air Pollution (http://www.aqmd.gov/rules/CIWG.htm) was approved by the AQMD Governing Board in September 2003. One of the recommendations of this White Paper was the development of a rule for reducing emissions from yard tractor at ports, rail yards, and distribution centers as an early action item in the 2004-2005 timeframe.

The modeling analysis performed as part of the 2003 AQMP demonstrates that significant emission reductions are required to meet the federal PM10 and ozone standards, especially reductions from mobile sources. In order to complement the proposed state and federal source control measures in the 2003 AQMP, the AQMD has introduced two new control measures which are aimed at achieving additional emission reductions from on- and off-road mobile sources. In addition to the two control measures, the Governing Board's 2003 AQMP adoption Resolution directs staff to conduct a feasibility study on developing control strategies (e.g., fleet rule) for yard tractors operated at ports and other facilities.

DESCRIPTION OF SOURCE CATEGORY

The vast majority of yard tractors operated in the Basin are used by private operators at the ports and rail yards, with smaller numbers used at warehouse/distribution centers. Yard tractors are generally used off-highway and within the confines of private properties and are thus classified under the off-road diesel engine category. A smaller percentage of yard tractors are powered by on-road certified engines such that, if properly equipped and licensed, can travel on a public roadway. As discussed later in this chapter, the significance of the type of engine (i.e., off-road or on-road) relates to the emission standards to which the engine is certified. On-road engines are subject to stricter emission limitation than are off-road engines.

Diesel powered yard tractors are available with engines of varying horsepower, generally ranging from approximately 150 – 250 horsepower. Yard tractors powered by off-road engines typically are of less horsepower than their on-road counterparts. The average life of a yard tractor is approximately ten years, though some port terminal operators have indicated a turnover of less than five years for tractors under severe use.

Based on recent studies performed by the Ports of Los Angeles and Long Beach in conjunction with CARB, EPA, and AQMD, there are approximately 1,100 yard tractors used at the ports each of which operate on average approximately seven hours per day. The emissions associated with the operations of these vehicles are estimated to be approximately 7.4 and 0.5 tons per day NOx and PM10, respectively.

Railroads also operate a relatively large number of yard tractors in the district. One of the two major railroad operators has approximately 160 yard tractors in service in the district; yard tractor population data from the other major railroad is not yet available. Yard tractors are also operated at distribution centers, but at lower populations per distribution center as compared to ports or rail yards.

REGULATIONS AND PROGRAMS AFFECTING YARD TRACTORS

There are a number of air quality control strategies and programs that target off-road equipment, including yard tractors. The following subsections discuss applicable control strategies of the AQMD, CARB, U.S. EPA, the Ports of Long Beach and Los Angeles, and others.

AQMD Programs

AQMD's Environmental Justice Program

In October 1997, AQMD's Governing Board adopted guiding principles and initiatives (http://www.aqmd.gov/ej/EJ_page.htm) to ensure environmental equity ("environmental justice") among Basin residents. At the September 2002 Public Hearing, the AQMD Governing Board approved 23 enhancements to the Environmental Justice program. The enhancements are intended to further identify and address concerns and serve as the basis for further outreach and problem-solving activities regarding short- and long-term environmental justice issues. The enhancements are divided into three categories: I. Further-Reduced Health Risks, II. Greater Community Access and Involvement, and III. Economic Incentives for Accelerated Mitigation. Environmental Justice Enhancement III-1 sets forth the following specific proposal for intermodal equipment:

> *Develop a low-emission and clean-equipment control measure for the category of off-road intermodal equipment, such as that operated at ports and large distribution centers.*

Environmental Justice enhancement III-1 cites yard tractors as a local source of PM10 and NOx emissions that have not been subject to strict emission requirements in the past, and requires staff to develop an estimated emissions inventory and provide emission reduction opportunities from this equipment category. Control options to be considered may include, but are not limited to, add-on (i.e. retrofit) controls, use of advanced fuels, and alternative technologies.

AQMD's Air Toxic Control Plan

The concept for a Air Toxics Control Plan (http://www.aqmd.gov/aqmp/atcp.html) is an outgrowth of the Environmental Justice principles and the Environmental Justice Initiatives adopted by the Governing Board in October 1997. Extensive air monitoring under Environmental Justice Initiative #2 (MATES II) and work under Environmental Justice

Initiative #10 (related to air toxics rules for new and existing sources) highlighted the need for a more systematic approach to reducing air toxics emissions.

The Air Toxics Control Plan is a planning document designed to examine the overall direction of the AQMD's air toxics control program. The plan is not required by state or federal law, nor is it a legally binding document. It includes strategies that aim to reduce toxic emissions and risk from both mobile and stationary sources. Strategies that are deemed viable and are within the AQMD's jurisdiction are presented to the Governing Board for further consideration through the normal public review process. Strategies that are to be implemented by other agencies are developed in a cooperative effort and the progress will be reported back to the AQMD Governing Board periodically. The Air Toxics Control Plan, which was originally adopted in 2000, is expected to undergo an update in 2004.

The Air Toxics Control Plan includes a number of control strategies targeting emissions from mobile sources (i.e., diesel engines), including AT-MBL-03: Control of Diesel Particulate Emissions Through Aftertreatment, AT-MBL-04: Control of Diesel Particulate Emissions through Engine Design Modification, and AT-MBL-05: Alternatively Fueled Engines.

2003 Air Quality Management Plan

To ensure continued progress toward clean air and comply with state and federal requirements, the AQMD in conjunction with CARB and the Southern California Association of Governments (SCAG) has prepared the 2003 revision to its Air Quality Management Plan (AQMP) (http://www.aqmd.gov/aqmp/AQMD03AQMP.htm). The 2003 AQMP employs up-to-date science and analytical tools and incorporates a comprehensive strategy aimed at controlling pollution from all sources, including stationary sources, on-road and off-road mobile sources and area sources.

The 2003 AQMP revision points to the urgent need for significant emission reductions to meet all federal criteria pollutant standards within the time frames allowed under the federal Clean Air Act. The majority of these reductions would be associated with mobile sources which are under state/federal jurisdiction and account for over 70% of ozone precursor emission in the South Coast Air Basin. Therefore, in order to complement the proposed state and federal source control measures, the AQMD has introduced two new control measures aimed at achieving additional emission reductions from on- and off-road mobile sources. These new control measures are briefly described below.

Control Measure #FSS-06: Further Emission Reductions from In-Use Off-Road Equipment and Vehicles proposes that in the event that the CARB or U.S. EPA does not develop aggressive programs to reduce emissions from in-use off-road equipment and vehicle categories (e.g., construction and industrial equipment, recreational vehicles, utility equipment), the AQMD would exercise its authority (or seek to obtain additional authority) to develop regulations to retrofit existing engines or accelerate the engine turn-over rate. Control Measure #FSS-07: Emission Fee Program for Port-Related Mobile Sources proposes an emissions fee program for in-use port related mobile sources, which would potentially apply to fleet operators of trucks and off-road equipment as well as railroads and shipping and trucking companies. The AQMD will use the monies collected from the program to implement projects with a focus to achieve emission reductions from in-use on-road and off-road mobile sources. When developing this control measure, staff may consider setting emission targets as a companion option in lieu of assessing emission fees.

In addition to these two control measures, the Governing Board's 2003 AQMP adoption Resolution directs staff to provide progress reports on the identification of new control measures to achieve long-term reductions, including the implementation of AQMD's Action Plan to Expedite Implementation of Long-Term Measures (2003 AQMP Resolution Attachment 2C). AQMD's Action Plan sets forth a commitment to conduct feasibility analyses for specific control strategies in accordance with the schedule outlined therein. The control of emissions from yard tractors is one of the control strategies identified in the Action Plan for which a feasibility analysis must be conducted in the 2003/2004 timeframe followed by a rule adoption in the 2004/2005 timeframe contingent upon the feasibility determination.

AQMD Technology Advancement Office Programs

The AQMD Governing Board established the Technology Advancement Office (TAO) in 1988 to assist the private sector in accelerating the development of low- and zero-emission technologies. Since its inception, AQMD has co-funded more than 250 projects involving a wide array of low-emission technologies and clean-fuel applications. TAO co-sponsors such projects with private companies, research institutes, other government agencies and universities. An example of a TAO project relative to yard tractors was the execution of a U.S. EPA grant to retrofit yard tractors with diesel oxidation catalysts at the Port of Long Beach in April 2003 (http://www.aqmd.gov/hb/03049a.html).

State Emissions Mitigation Fund

In 2001, Governor Davis created a statewide NOx and PM Reduction Program to mitigate excess emissions from peaker power generation units that were needed to alleviate the power crisis in California. To recognize State funds from CARB, the AQMD Governing Board established a State Emissions Mitigation Fund at its July 20, 2001 public meeting. Under this program, CARB allocated the use of $1,000,000 for projects at the Port of Los Angeles to reduce NOx and PM emissions from re-powering diesel-fueled marine vessel engines, yard tractors, portside equipment, and the use of alternative fuels and emission control technologies. As required by the program, the Port of Los Angeles matched CARB's contribution with an additional $1,000,000 through a Memorandum of Agreement, which was executed on February 12, 2003. In discussions between the Port of Los Angeles staff and AQMD staff, it was decided that the available funds be evenly allocated between marine vessels and landside equipment to maximize the air quality benefits for the available funds. A component of this program is to install diesel oxidation catalysts on marine terminal equipment (including yard tractors), a portion of which is to be used in conjunction with emulsified diesel fuel. According to the Port of Los Angeles, approximately 300 diesel oxidation catalysts have been installed to date; approximately 300 more will be installed pending completion of the appropriate contracts.

CARB Programs

Engine Standards

The federal Clean Air Act grants California the authority to adopt and enforce standards to control mobile source emissions within California that are as stringent, or more stringent, than the federal requirements. California has adopted emission standards for diesel engines used in yard tractors that are equivalent to federal standards.

The large majority of yard tractors are used off-highway and within the confines of private property and thus are considered off-road equipment and must meet off-road diesel engine standards. A small percentage of yard tractors are designed and licensed for on-road applications such that they can travel on a public roadway. Yard tractors using on-road engines (whether or not licensed for on-road operation) must meet on-road diesel engine standards. Off-road and on-road diesel engine standards adopted by CARB and approved by U.S. EPA are discussed in the subsections below.

Off-Road Diesel Engine Standards

In January 1992, CARB adopted exhaust emission standards for off-road diesel-cycle engines 175 hp and greater to be effective starting with the 1996 model year engines[2]. Prior to 1996, emissions from off-road diesel engines between 175 and 750 hp were uncontrolled. According to CARB, estimates of NOx emission levels from uncontrolled off-road engines range from 8.2 grams per break horsepower-hour (g/bhp-hr) to 14 g/bhp-hr. In January 2000, CARB adopted amendments to existing California emission standards which harmonized them with the federal standards (adopted August 1998). These standards consist of a tiered structure of emission limits based on engine power. Table 1-1 summarizes the existing and future emission standards for off-road engines applicable to yard tractors[3].

On-Road Diesel Engine Standards

CARB first began regulating new on-road heavy-duty vehicles in 1969 with exhaust standards for ROG and carbon monoxide (CO). Since that time, CARB has expanded its control program to include NOx and PM emission control requirements. Since 1998, heavy-duty diesel engines, exclusive of urban bus engines[4], have been required to certify to a 4.0 g/bhp-hr NOx standard and a 0.10 g/bhp-hr PM standard. These standards are further reduced in 2004 and again in 2007 as shown in Table 1-2.

[2] Emission standards were adopted with different effective dates for off-road diesel engines with other horsepower-ratings.

[3] Yard tractor engines typically fall within the approximately 150-250 hp range.

[4] Urban bus engines produced for sale in California have generally been subject to more stringent emission standards sooner than other classes of heavy-duty diesel engines; hence, they have been required to certify to a 4.0 g/bhp-hr NOx standard and a 0.05 g/bhp-hr PM standard since 1996.

Table 1-1
Off-Road Compression- Ignition (Diesel) Engine Standards
(g/bhp-hr)

Engine Size / Model Year	NMHC+NOx*	HC	NOx	PM	CO
100 to < 175 hp					
1997 (Tier 1)	--	--	6.9	--	--
2003+ (Tier 2)	4.9	--	--	0.22	3.7
2007+ (Tier 3)	3.0	--	--	0.22	3.7
175 to < 300 hp					
1996 (Tier 1)	--	1.0	6.9	0.40	8.5
2003+ (Tier 2)	4.9	--	--	0.15	2.6
2006+ (Tier 3)	3.0	--	--	0.15	2.6

NMHC = non methane hydrocarbons
* NOx fraction default value = 0.95 (Carl Moyer Program Guidelines, Table 3.2)

Table 1-2
On-Road Diesel Engine Standards
(g/bhp-hr)

	NMHC+NOx*	NMHC	NOx	PM	CO
1998	--	1.2 (THC = 1.3)	4.0	0.10	15.5
2004					
Option 1	2.4	--	--	0.10	15.5
Option 2	2.5	0.50	--	0.10	15.5
2007	--	0.14 **	0.20 **	0.01	--

NMHC = non methane hydrocarbons
* NOx fraction default value = 0.95 (Carl Moyer Program Guidelines, Table 3.2)
** Applicable to phase-in schedule based on % of sales: 50% from 2007 to 2009 and 100% in 2010. It is expected that manufacturers will produce engines meeting 1.2 g/bhp-hr for 2007-09 model years under allowed averaging provision.

CARB's Mobile Source Control Strategy

The 2003 State and Federal Strategy for the California State Implementation Plan (http://www.arb.ca.gov/planning/sip/stfed03/stfed03.htm) includes three control measures which are applicable to equipment such as yard tractors (OFF-RD-CI-1, OFF-RD-CI-2, and ON-RD HVY-DUTY-3). Control Measure OFF-RD-CI-1 targets in-use PM emissions from the existing fleet of off-road vehicles (though CARB staff expects VOC reductions to be realized as well). The control measure envisions operators selecting emission reduction strategies such as retrofit control technology, engine repowering, old vehicle retirement, or replacement of vehicle with new model. Control Measure OFF-RD-CI-2 proposes to implement a registration and inspection program for existing heavy-duty off-road equipment to detect excess emissions. Control measure ON-RD HVY-DUTY-3 is a comprehensive measure intended to control emissions from both new and in-use heavy duty on-road vehicles. The measure's individual components are: PM In-Use Emission Control Fleet Rules, Engine Software Upgrades (for 1993 through 1998 model year engines using "defeat devices"), On-Board Diagnostics, Manufacturer-Required In-Use Vehicle Testing, and Reduced Truck and Bus Idling. The control strategies set forth in these three control measures are scheduled for adoption between 2003 and 2009.

As part of the adoption proceedings for the 2003 State and Federal Strategy for the California State Implementation plan, CARB also committed to achieve additional emission reductions from on- and off-road mobile sources as set forth in Control Measure ARB-Short-Term. These emission reductions are in addition to that specified in other short-term measures (e.g., OFF-RD-CI-1, OFF-RD-CI-2, and ON-RD HVY-DUTY-3) and include possible regulations to further control emissions from heavy-duty diesel trucks and construction/industrial off-road diesel equipment.

CARB's Diesel Risk Reduction Program

In September 2000, CARB approved the Diesel Risk Reduction Plan which identified the impacts of and current technologies to control diesel PM, and outlined measures necessary to reduce diesel PM (http://www.arb.ca.gov/diesel/dieselrrp.htm). The goal of the Diesel Risk Reduction Plan is to reduce diesel PM emissions and the associated health risk by 75 percent in 2010 and 85 percent by 2020. The Plan identifies the steps CARB will be taking to develop specific regulations to reduce diesel PM emissions.

The programs and control strategies developed under the Diesel Risk Reduction Plan feed back into the State and Federal SIP control measures that impact yard tractors. For example, the retrofit control technologies developed/evaluated under this program are those anticipated to be implemented as part of control measure OFF-RD-CI-1.

Carl Moyer Memorial Air Quality Standards Attainment Program

The Carl Moyer Program provides funds on an incentive-basis for the incremental cost of cleaner than required engines and equipment. Eligible projects include cleaner on-road, off-road, marine, locomotive and stationary agricultural pump engines, as well as forklifts, airport ground support equipment, and auxiliary power units. The program achieves near-term reductions in emissions of NOx and PM, which are necessary for California to meet its clean air commitments under the SIP. Public or private entities that operate eligible engines or equipment in California can participate by applying directly to their local air pollution control districts. CARB is responsible for developing the guidelines that districts use to implement the program (http://www.arb.ca.gov/msprog/moyer/2003moyerguide.pdf). CARB also develops an allocation of the funding to the districts.

The AQMD has approved project funding under the Carl Moyer Program for a number of yard tractor projects. These include the replacement of diesel-powered yard tractors with LPG-powered yard tractors. Five LPG yard tractors purchased with Carl Moyer Program funding are still in service at a terminal in the Port of Los Angeles. However, these yard tractors are reportedly used less than half the number of hours as comparable diesel yard tractors due to inferior turning radius, fuel economy, and torque, excessive noise, and higher maintenance.

Other Programs

U.S. EPA's Voluntary Diesel Retrofit Program

The U.S. EPA's plan to reduce pollution from new diesel engines is a two-step approach that reduces emission standards for diesel engines in 2004 and again in 2007. To address pollution from diesel construction equipment and heavy-duty vehicles that are currently on the road today, U.S. EPA has developed a Voluntary Diesel Retrofit Program. This program helps fleet operators, air quality planners, and retrofit manufacturers design and implement voluntary diesel retrofit programs. One component of this program is a voluntary process through which manufacturers of retrofit equipment can have the performance of their technologies objectively verified and placed on EPA's Verified Retrofit Technology List.

Port of Long Beach

The Long Beach Board of Harbor Commissioners has approved a comprehensive Air Quality Improvement Program whose goal is to achieve measurable, long-term reductions in air pollution, especially diesel emissions, from port operations. The Air Quality Improvement Program (http://www.polb.com/html/4_environment/air.html), approved in April 2003, is divided into four categories: Alternative Fuels and Clean Diesel, Operational Improvements, Vessel Emissions, and Particulates. The Alternative Fuels and Clean Diesel and Operational Improvements programs are applicable to yard tractors and are briefly described here.

<u>Alternative Fuels and Clean Diesel</u>

The Port of Long Beach is participating in efforts to install new emission control technology in equipment operated by tenants and in railroad locomotives operated largely within the Port. Under an agreement with CARB, the Port is providing $2 million to help tenants convert to the exclusive use of alternative diesel fuel and install pollution-control devices on diesel equipment. To date, approximately 300 yard tractors have been retrofitted with diesel oxidation catalysts with the remainder expected to be retrofitted by the end of April 2004. In addition, two port terminals are using emulsified diesel fuel instead of diesel fuel in their yard tractors and other port-related off-road equipment.

Additionally, the Port of Long Beach is committed to conducting at least one pilot project to evaluate the feasibility of using gaseous fuels (LNG or LPG) in heavy-duty terminal equipment such as yard tractors and mobile cranes.

<u>Operational Improvements</u>

The Port of Long Beach has also instituted several operational improvements intended to improve air quality, including:

- A program to convert Port-owned vehicles to cleaner burning engines such as compressed natural gas and hybrid/electric and to install pollution control devices such as diesel oxidation catalysts on heavy-duty maintenance equipment operated by the Port.

- A tariff requiring tenants to prepare plans to reduce emissions of particulates and NOx by 2008.
- Partnering in the Gateway Cities Clean Air Program, together with the Gateway Cities Council of Governments and CARB. The program provides financial incentives to independent truckers and trucking companies to trade in their 1983 and older diesel trucks for newer used models with cleaner-burning engines.

Port of Los Angeles

The Port of Los Angeles has implemented a number of programs to promote air quality throughout the harbor (http://www.portoflosangeles.org/Environmental/airquality.htm), including those relative to port-related equipment such as yard tractors. Programs pertinent to yard tractors include:

Settlement Agreement for China Shipping Terminal (2003)

In 2001, two environmental organizations joined with local community groups in a lawsuit against the Port of Los Angeles, charging that the port failed to conduct an Environmental Impact Report (EIR) before constructing container-handling facilities at a 174-acre terminal the port leased to the China Shipping Holding Co. The state Court of Appeals decided in favor of the community and environmental groups leading to a settlement that required preparation of an EIR, a commitment to significant mitigation, and the payment of $50 million over a four-year period for environmental mitigation measures.

As part of the settlement, all of the yard tractors used at the terminal will run on cleaner alternative fuels and at least 70 percent of the ships using the terminal will be electrified while at berth. In addition, the port committed to replacing two existing 16-story cranes with lower profile cranes that are approximately half the height.

The stipulated judgment allocates the mitigation funds as follows:

$20 million for air quality improvements;

$20 million for aesthetic improvements; and

$10 million toward the Gateway Cities program (see below).

Diesel Oxidation Catalyst Program (May 2003)

With funding form the State and the Port of Los Angeles, container terminal operators are expected to install nearly 600 diesel oxidation catalysts in their marine terminal equipment engines, including yard tractors, side and top picks, forklifts and transtainers. Approximately 300 have been installed to date. Another 300 are awaiting completion of appropriate contracts.

Electric And Alternative Fuel Vehicles (ongoing since 1990s)

Approximately 35% of the Port of Los Angeles' on-and off-road fleet has been converted to electric or alternate fuel vehicles. These include heavy-duty vehicles as well as passenger vehicles. The Port is also helping tenants convert to using emulsified diesel fuel in their off-road mobile equipment (including yard tractors). The additional cost of emulsified diesel has been an impediment to the exclusive use of this fuel by all port tenants.

Gateway Cities Program

The Gateway Cities Council of Governments has teamed with the CARB and the Port of Long Beach to create the Gateway Cities Clean Air Pilot Program (http://www.gatewaycog.org/cleanairprogram/index.html). The goal of the pilot program is to reduce emissions of NOx and PM from diesel-fueled vehicles and equipment that operate in the Port of Long Beach and the 27 cities that are members of the Gateway Cities Council of Governments. The three elements of the Pilot Program include replacement of off-road equipment, installation of PM traps on fleet vehicles, and diesel truck fleet modernization. The fleet modernization component of the program offsets the cost of replacing 1983 and older on-road heavy-duty diesel vehicles with 1994 and newer model year vehicles. As of November 2003, total funding for the program has been in excess of $4 million and 155 trucks have been modernized. Depending on various factors - such as the model years of the older and newer truck and the actual miles that the newer truck will be driven over the five-year life of the project - an estimated 1/2 ton to one ton of NOx emissions will be reduced per year for each truck, or up to five tons of NOx reduced per truck over five years. Diesel PM will be reduced by an estimated 1/5 of a ton per year for each newer truck deployed, or about one ton of PM reduced per truck over five years.

INTRODUCTION

There has been considerable public and private effort to develop emission control strategies for diesel engines. The AQMD has participated in the development of these technologies through its Technology Advancement Office that leverages AQMD funds with funds from other agencies and private interests into research, development, and commercialization. Mobile source diesel emission control strategies include retrofit controls, alternative diesel fuels, integrated hardware systems and hardware systems with alternative diesel fuel, and engine adjustments. Alternative fueled (i.e., natural gas, liquid propane gas) engines capable of performing the work done by diesel engines are also available.

Most of the efforts to develop mobile source diesel emission control technologies have been directed toward on-road diesel applications. As discussed in detail below, the only technologies applicable to yard tractors (i.e., off-road engines) which are verified by CARB to achieve NOx and PM emission reductions relative to conventional diesel are a combined diesel oxidation catalyst/crankcase emission control system and an emulsion of diesel fuel and water. Furthermore, while yard tractors powered by alternative fuel engines are available, concerns have been expressed by yard tractor operators regarding the applicability of alternative fuel equipment because of the power requirements, fuel economy, fueling infrastructure, and reliability under intense operations.

The technologies evaluated in this chapter are based on CARB's verification of the emission reductions and durability of diesel emission control technologies. The CARB Board originally adopted the Diesel Emission Control Strategy Verification Procedure in May 2002 (http://www.arb.ca.gov/diesel/verdev/reglang051203rev.pdf) and approved amendments in February 2004 (http://www.arb.ca.gov/regact/verpro03/verpro03.htm). Under this procedure, CARB verifies control technology for specific engine manufacturers, model years, engine families and series under the verification classification set forth in Table 2-1[5].

Table 2-1
CARB Verification Classifications for Diesel Emission Control Strategies

Pollutant	Reduction	Classification
PM	< 25%	Not verified
	25% to > 50%	Level 1
	50% to > 85%	Level 2
	≥ 85% or ≤ 0.01 g/bhp-hr	Level 3
NOx	< 15	Not verified
	≥ 15%	Verified in 5% increments

[5] It should be noted that CARB's diesel emission control strategy verification procedure is a different process from CARB's engine certification procedure. New motor vehicles and engines must be certified by CARB for emission compliance before they are legal for sale, use, or registration in California.

CARB also verifies emission reductions resulting from the use of alternative diesel fuels under an Interim Procedure for Verification of Emission Reductions for Alternative Diesel Fuels (http://www.arb.ca.gov/fuels/diesel/altdiesel/altdiesel.htm). The procedure provides the process for obtaining CARB verification of emission reductions of PM and NOx for alternative diesel fuels[6].

Similar to CARB's diesel control strategy verification procedure, U.S. EPA evaluates the emission reduction performance of retrofit technologies, including their durability, and identifies engine operating criteria and conditions that must exist for these technologies to achieve those reductions (Voluntary Diesel Retrofit Program Verification Process, http://www.epa.gov/otaq/retrofit/retrofittech.htm). The process results in the percent reduction (of verified or tested levels) that U.S. EPA will recognize for emission reductions within state air quality plans. Another U.S. EPA verification program, the Environmental Technology Verification (ETV) Program (http://www.epa.gov/etv/index.html), develops testing protocols and verifies the performance of innovative environmental technologies (including emission control technologies for off-road equipment such as yard tractors).

EMISSION CONTROL TECHNOLOGIES

Alternative diesel fuels, retrofit technologies, alternative fuels, and the use of on-road certified engines are options for controlling diesel emissions from yard tractors operated in the district and are discussed in the following subsections. Control technologies which require further development or commercialization to be applicable to yard tractors are also briefly described in this chapter.

Alternative Diesel Fuels Currently Applicable to Yard Tractors

CARB defines an alternative diesel fuel as a fuel that can be used in a diesel engine without modification to the engine and that is not just reformulated diesel fuel. These include emulsified diesel, biodiesel, ethanol diesel, and Fischer-Tropsch fuels. Emulsified diesel is the only alternative diesel fuel currently being used in yard tractor operations in the Basin and is discussed below.

Emulsified Diesel

A commercially available alternative diesel fuel that reduces both NOx and PM emissions is an emulsion of diesel fuel and water which includes an agent to keep the fuel and water from separating. Blending water with diesel fuel lowers peak combustion temperature, thereby producing less NOx emissions. Emulsified fuel also increases fuel atomization which results in lower PM emissions. Three companies currently produce diesel fuel emulsion systems which are used by fuel marketers/distributors to produce emulsified diesel fuel. Fuel marketers/distributors blend diesel fuel, purified water and proprietary fuel additive chemistry to produce a water-in-diesel fuel emulsion.

[6] For the purpose of this procedure, alternative diesel fuels mean fuels that are used in diesel engines that are not reformulated diesel fuels as defined in section 2281 and 2282 of Title 13, of the California Code of Regulations and do not require engine or fuel system modifications to operate on such fuels.

CARB has granted alternative diesel fuel emissions certification for emulsified diesel through its fuels certification procedure. However, CARB must first complete a multi-media analysis for toxics before issuing a verification for emulsified fuel as a diesel emission control strategy. CARB staff expects that this technology will achieve a Level 2 verification, or a minimum of 50 percent PM reduction. The alternative diesel certifications for the three emulsified diesel products currently available confirm reductions of NOx and PM emissions of approximately 15% and 60%, respectively, as compared to standard diesel. CARB has also determined that emulsified diesel will not result in an increase in toxics emissions, and hydrocarbon emissions are at least 25% lower than any applicable diesel vehicle emission standard. U.S. EPA has also verified emulsified diesel for heavy duty, on- and off-road 2 and 4 cycle engines to achieve reductions of 16 to 58% in PM and 9 to 20% in NOx.

Vehicles using emulsified diesel require no engine modifications to the engine or fuel system, and, based on usage to date, there are currently no significant technical issues associated with the use of this fuel. Relative to diesel fuel, however, there is an increase in HC and CO emissions and a fuel penalty of approximately 15%.

A number of end-users are using emulsified fuel in a variety of vehicles and applications such as yard tractors, school and transit buses, underground mine equipment, construction equipment, generators, port operations equipment, trucks and tractors, small equipment such as welders and air compressors. Both the Port of Long Beach and the Port of Los Angeles have programs in place to promote the use of emulsified diesel fuel in off-road mobile equipment (including yard tractors) at the ports. Two terminals at the Port of Long Beach are currently using emulsified diesel in their off-road equipment.

Alternative Diesel Fuels with Potential Long-Term Applicability

Some alternative diesel fuels currently have certain limitations that make them unavailable in the near-term. Those alternative diesel fuels that may be applicable to controlling emissions from yard tractors with future product development/commercialization are briefly discussed in the following subsections.

Fischer-Tropsch Fuel

The Fischer-Tropsch technology uses CO and hydrogen to convert coal, natural gas, or other hydrocarbons to a high-value, clean-burning fuel that is virtually interchangeable with conventional diesel fuels and can be blended with diesel at any ratio with no engine modification. While actual emissions will vary with engine design, emissions of NOx are reduced because of Fischer-Tropsch fuels' high cetane number and, since the fuels contain a very low sulfur and aromatic content, they produce virtually no particulate emissions. Researchers also expect reductions in hydrocarbon and CO emissions. Controlled tests conducted in 1998 by the National Renewable Energy Laboratory (U.S. Department of Energy) and West Virginia University showed that Fischer-Tropsch fuels can be substituted in heavy-duty vehicles without any detectable loss in performance while reducing NOx and PM emissions by approximately 12% and 24%, respectively. Staff is not aware of any testing of Fischer-Tropsch fuels in off-road applications.

At present, Fischer-Tropsch fuels are expensive to produce on a large scale, although research is underway to lower processing costs. Consequently, the availability of Fischer-Tropsch fuels is currently limited.

Biodiesel

Though the diesel engine was originally developed with the intention of running it on a variety of fuels, including vegetable oil, it has historically been run on petroleum-derived fuel (petrodiesel) because it has been the least expensive fuel available. Today, the diesel engine is still capable of running on “biodiesel” fuel with little or no modification to the engine or fuel system. Biodiesel can be produced from a variety of renewable sources, including soybean oil, canola oil, sunflower oil, cottonseed oil, and animal fats. Biodiesel is usable in its purest form, known as “neat biodiesel” or B100. It is also used as a blend with petrodiesel, the most common of which is a 20 percent biodiesel and 80 percent petrodiesel blend (known as B20).

Due to the increasing interest in the use of biodiesel, the U.S. EPA conducted a comprehensive analysis of the emission impacts of biodiesel using publicly available data, the majority of which was collected on 1997 or earlier model year heavy-duty on-road engines (http://www.epa.gov/otaq/models/analysis/biodsl/p02001.pdf). For soybean-based B20 biodiesel, the estimated emission impacts are: +2.0% for NOx, -10% for PM, -21% for HC, and -11.0% for CO. A reduction in aggregate toxics is expected, but the impacts differ from one toxic compound to another. The report states that the estimates of biodiesel impacts on emissions from pre-1997 engines may be less accurate for future fleets due to on-going changes in engine design. The report could not say with confidence that off-road engines would respond to biodiesel in the same way that heavy-duty highway engines do.

Biodiesel has been used successfully in heavy-duty diesel-fueled vehicles. There are no technical limitations to the use of biodiesel; rather the limitations concern cost and the increased NOx emissions associated with biodiesel use (there is also a 1-2% reduction in fuel economy). B100 is not currently verified by CARB as an alternative fuel or as a diesel emission control strategy. U.S. EPA has listed biodiesel as a verified control technology as part of its Voluntary Diesel Retrofit Program. The U.S. EPA listing shows verified emission reductions of biodiesel (1 to 100%) ranging from 0 to 47% for both PM and CO, 0 to 67% for HC, and 0 to -10% for NOx.

Ethanol Diesel

Ethanol blended diesel consists typically of a mixture of #2 diesel (~80%), anhydrous denatured alcohol (7 to 15%), and a blending additive with cetane improver (~5% max). Ethanol diesel blended fuel has demonstrated a reduction in PM emissions, which can be on the order of 20% to 30%. However, emissions of CO and HC can increase, thus possibly requiring an oxidation catalyst. NOx may or may not be affected depending on engine design. Aldehyde emissions are expected to increase with alcohol blended diesel fuel.

Ethanol diesel is likely to remain an experimental fuel until flammability concerns and health effects testing are addressed, and the economic infrastructure developed. Engine manufacturers recommend that until the safety and other issues are resolved, use of ethanol diesel or other alcohol/diesel blends should not be used in their products.

It should be noted that emission reductions from one ethanol diesel product have recently been conditionally verified pursuant to CARB's Interim Procedure for Verification of Emission Reductions from Alternative Diesel Fuels to be 1.6% NOx and 20% PM. CARB staff has also determined that measurements of specified emissions indicate no net increase in toxicity, and that hydrocarbon emissions are at least 25% lower than any applicable diesel vehicle emission standard. However, the conditional verification does not address the appropriate use of the product in regards to possible impacts on fuel safety and handling, engine durability or performance and does not address possible multi-media environmental impacts that may result from its use. CARB staff may modify or withdraw verification based on evidence supported by a multi-media assessment or future durability and safety evaluations of the fuel.

Retrofit Technology Currently Applicable to Yard Tractors

The only retrofit technology[7] applicable to yard tractors that is currently verified by CARB as a diesel emission control strategy is a combined diesel oxidation catalyst/crankcase emission control system. U.S. EPA has not verified any retrofit technology for off-road engines under either its Voluntary Diesel Retrofit Program or Environmental Technology Verification Program.

Diesel Oxidation Catalyst

A diesel oxidation catalyst (DOC) consists of a steel housing that contains a porous, active base or precious catalytic metal layer applied to a high geometric surface area substrate. As the exhaust gas passes over the catalyzed substrate, chemical reactions occur which reduce CO, HC, and PM into carbon dioxide and water. Some manufacturers integrate HC traps (zeolites) and sulfate suppressants into their oxidation catalysts. HC traps enhance HC reduction efficiency at lower exhaust temperatures and sulfate suppressants minimize the generation of sulfates at higher exhaust temperatures. DOCs are often integrated into a muffler which is used to replace the standard muffler. DOCs have also been designed to fit close-coupled to the manifold in the existing engine compartment.

DOCs can reduce total PM emissions by up to 50% depending on the amount of the soluble organic fraction in the PM and the amount of sulfur in the fuel. Oxidation catalysts are also effective in controlling CO and toxic HC emissions with reductions in emissions of these pollutants of 50% for base metal catalysts and up to 90% for precious metal catalysts. CARB has verified a combined DOC/closed crankcase filtration system for some four-stroke, turbocharged 1996-2003 model year off-road diesel engines ranging from 150 to 600 hp (which may be used in yard tractors) to reduce emissions of diesel PM by an average of at least 25%. No DOC catalyst has been verified by U.S. EPA for off-road engines.

DOC technology is commercially available and is readily applied to virtually the entire range of off-road engine applications. This technology has been used on over 250,000 off-road vehicles and equipment including yard tractors, mining vehicles, skid steer loaders, forklift

[7] For the purposes of this White Paper, retrofit technology refers to non-fuel related diesel control technologies.

trucks, construction vehicles and stationary engines, as well as, over 35,000,000 diesel passenger cars. In conjunction with their emulsified diesel program, both the Port of Long Beach and the Port of Los Angeles have programs which subsidize the cost of installing DOCs in off-road mobile equipment (including yard tractors) used by terminal operators. Based on preliminary estimates, the Port of Long Beach has ordered approximately 600 DOCs with approximately 300 installed to date. Of the 300 installed DOCs, over 100 have been retrofitted into yard tractors. It is anticipated that the majority of off-road mobile equipment operating at the ports will install diesel oxidation catalysts by mid-2004.

Crankcase Emission Control

In most turbocharged aftercooled diesel engines, the crankcase breather vents unburned fuel and combustion byproducts to the atmosphere. While a rudimentary filter is often installed on the crankcase breather, emissions of particulate matter through the breather is substantial and may exceed 0.7 g/bhp-hr during idle conditions on recent model year engines.

Multi-stage filter systems capable of eliminating crankcase emissions are commercially available. Typical systems consist of a filter housing, a pressure regulator, a pressure relief valve and an oil check valve. These systems are designed to collect, coalesce, and return the emitted lube oil to the engine's sump. Filtered gases are returned to the intake system, balancing the differential pressures involved. Service lives of 500 to 1500 hours or more can be designed into the system, after which its replaceable filter must be changed to maintain appropriate system pressures and filtration efficiency.

As discussed above, CARB has verified a combined DOC/closed crankcase filtration system for certain off-road diesel engines.

Retrofit Technology with Potential Long-Term Applicability

Some retrofit technologies currently have certain limitations that make them unavailable for off-road applications such as yard tractors in the near-term. Those retrofit technologies that may be applicable with future product development are briefly discussed in the following subsections.

Diesel Particulate Filter

In general, a diesel particulate filter (DPF) consists of a porous substrate that permits gases in the exhaust to pass through but traps the PM. DPFs can be divided into two types of systems - passive and active - depending on the method by which the filter is regenerated. A passive catalyzed DPF reduces PM through filtration and CO and hydrocarbon emissions through catalytic oxidation with no outside source of energy required for regeneration. The successful application of a passive DPF is primarily determined by the average exhaust temperature at the filter's inlet and the rate of PM generated by the engine. In general, yard tractors do not meet the minimum exhaust temperature required for passive DPF technology.

An active DPF system uses an external source of heat to oxidize the PM. Common methods of generating additional heat for oxidation involve electrical regeneration by passing a current through the filter medium, injecting 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 to alert the operator that regeneration is needed and require the operator to initiate the regeneration process.

Numerous studies have documented the effectiveness of DPFs in both on- and off-road applications with PM reductions of 80 – 90%. DPFs are commercially available today with over 70,000 on-road, heavy-duty vehicles and 400,000 diesel passenger cars having been equipped with the technology. CARB and U.S. EPA has verified a number of passive DPFs for use in on-road applications; no active DPFs have been verified. Thus, while DPFs are proven to provide high emissions reductions, further development of the technology will be required to make DPFs applicable to yard tractors and other off-road applications that do not meet the minimum engine exhaust temperature requirements of the current technology.

Flow Through Filters

Flow through filter (FTF) technology is a relatively new technology for reducing diesel PM emissions. Unlike a DPF, in which only gasses can pass through the substrate, the FTF does not physically trap PM. Instead, exhaust flows through a medium that has a high density of flow channels which create turbulent flow conditions. The medium is typically treated with an oxidizing catalyst that is able to reduce emissions of PM, HC, and CO, or used in conjunction with a fuel-borne catalyst. Any particles that are not oxidized with the FTF flow out with the rest of the exhaust and do not accumulate. The filtration efficiency of an FTF is lower than that of a DPF, but the FTF is much less likely to plug under unfavorable conditions, such as high PM emissions, low exhaust temperatures and emergency circumstances. The FTF, therefore, is a candidate for use in applications that are unsuitable for DPFs, though there are currently no known applications of this technology to off-road engines.

NOx Adsorber Catalyst

NOx adsorbers act to store NOx emissions during lean engine operation and release the stored NOx by periodically creating a rich exhaust environment by either engine operation or the injection of a reductant in the exhaust stream. When released, the NOx is converted to N2 by a three-way catalytic reaction. In laboratory tests, NOx adsorbers have demonstrated the ability to control up to 90 percent or more of the engine-out NOx emissions over a broad temperature range.

NOx adsorber catalysts are currently being used commercially in light-duty gasoline direct injection engines. This technology is also undergoing extensive research and development in anticipation of the U.S. 2007 on-road heavy-duty diesel engine regulations and to help significantly reduce NOx emissions from light-duty diesel vehicles. NOx adsorber technology is also expected to be available for use with off-road diesel engines in the future.

Lean NOx Catalyst

The conversion of NOx to molecular nitrogen in the exhaust stream of diesel engines requires sufficient quantities of reductant (HC, CO or H2) which under typical engine operating conditions are not present to facilitate the conversion of NOx to nitrogen. Lean NOx catalysts add a small amount of diesel fuel or a reducing agent to the exhaust stream to facilitate catalytic conversion of NOx to nitrogen and water vapor. Since the fuel used to reduce NOx does not produce mechanical energy, lean NOx catalysts typically operate with a fuel penalty of about 5%. Currently, peak NOx conversion efficiencies typically are around 10% to 20%.

Though only a limited number of vehicles have been equipped with lean NOx catalyst systems in the U.S., a low NOx control version of this technology has been incorporated into the exhaust systems of European passenger cars equipped with DOCs. These systems have achieved NOx reductions of about 15 percent. A higher efficiency version of this technology capable of achieving 50 to 70 percent NOx reductions is under development. Advances have been made in improving the durability, control efficiency and operating windows of this technology which may make it available for off-road applications in the future.

ALTERNATIVE FUELS

The alternative fuels[8] which may be capable of replacing diesel fuel for use in yard tractors and other off-road equipment are compressed natural gas, liquefied natural gas, and liquefied propane gas.

Compressed Natural Gas (CNG)

Two types of engine operating cycles are currently being used for heavy-duty CNG engines. Spark ignited engines use spark plugs to ignite the natural gas fuel mixture in the combustion chamber, similar to a light-duty automobile engine. Compression pilot ignition engines inject a small amount of diesel along with natural gas into the combustion chamber. The heat generated by compressing this mixture ignites the diesel fuel that in turn ignites the natural gas mixture, operating much like a conventional diesel engine.

Natural gas trucks typically have a shorter driving range than their diesel counterparts as a result of natural gas having a lower energy density (approximately 29% of diesel fuel) and the difficulty in packaging the high pressure storage cylinders on the vehicle. Because of the reduced energy density, CNG vehicles require more frequent refueling. Natural gas vehicle fueling abilities can range from a very small slow-fill for refueling of private vehicles or large fast-fill for refueling a fleet of heavy-duty vehicles. Slow-fill systems are simpler in design and cost less than fast-fill stations. However, slow-fill stations require several hours to refuel compared to the two-five minutes needed with fast-fill systems.

At least one engine manufacturer produces natural gas (CNG and LNG) engines applicable to yard tractors. For the 2004 model year engine, a family emissions level for NOx has been established at 1.8 g/bhp-hr, or 28% lower than the on-road level of 2.5 g/bhp-hr and 63% lower than the off-road level of 4.9 g/bhp-hr The PM level is certified at 0.1 g/bhp-hr or 33% lower than the off-road standard of 0.15 g/bhp-hr.

There are almost 130,000 natural gas vehicles on the road in the United States today and more than two million worldwide. However, this technology has disadvantages for yard tractor operations due to its low energy density and relatively high cost of fuel infrastructure.

[8] For the purposes of this White Paper, alternative fuels refers to natural gas and propane.

While a freight trucking company in Oregon converted 10 yard tractors to CNG and purchased seven more CNG yard tractors in 2000 by taking advantage of Oregon's 35 percent Business Energy Tax Credit, there are no known CNG yard tractors in operation in the district.

Liquefied Natural Gas (LNG)

Most heavy-duty LNG trucks are produced by replacing the diesel fuel tanks on an existing or new truck chassis with LNG tanks and fuel system components and either installing a new original equipment manufacturer (OEM) natural gas engine or converting the existing diesel engine. There are no discernible differences in LNG vehicle performance, operation, and utility when compared with diesel. The high ignition quality of LNG is similar to that of diesel, providing for similar durability and engine life overall. The main disadvantages are the reduced energy density (57% as compared to diesel), the cryogenic nature of LNG and the necessity for storage in unique vessels and limited liquid hold time.

Fuel supply options for LNG vehicles include central liquefaction facilities, on site liquefaction and imported LNG. An LNG refueling station generally consists of a storage tank, a fuel transfer system that typically uses a pump or differential pressure, and dispenser equipment including a refueling connector, a cryogenic hose, and a metering control system. LNG refueling is faster than CNG, but the hoses and connectors used for LNG are more cumbersome.

LNG is particularly well-suited for large, heavy duty, centrally fueled fleets, large off-road vehicles, and marine applications. At least one engine manufacturer produces natural gas (CNG and LNG) engines applicable to yard tractors (see CNG discussion above for emission levels), and a supermarket chain in Sacramento has recently purchased two LNG yard tractors. Additionally, both the Port of Long Beach and at least one terminal operator at the Port of Los Angeles will each obtain one LNG yard tractor in early 2004 and independently test their effectiveness in performing the work currently done by yard tractors using diesel fuel. Other factors to be evaluated include fueling infrastructure requirements, mechanical considerations, durability, safety, and costs.

Liquefied Petroleum Gas (LPG)

Liquefied petroleum gas (LPG) consists mainly of propane (other components include propylene, butane, and butylene in various mixtures). The components of LPG are gases at normal temperatures and pressures. LPG is a by-product from two sources: natural gas processing and crude oil refining. About 55% of the LPG processed in the U.S. is from natural gas purification while the remaining 45% comes from crude oil refining.

LPG has an energy density of approximately 35% of diesel. Since LPG is stored under pressure both inside the vehicle and in the refueling tanks, special refueling equipment is needed to transfer the pressurized liquid from the storage tanks to the vehicle and to ensure that no LPG escapes during refueling.

There are more than 350,000 on- and off-road propane-powered units in the United States, while over four million vehicles use it worldwide. Propane is used in both light- and medium-duty vehicles. Estimates have placed the number of registered propane-powered vehicles in California as high as 40,000. Propane has been used as a transportation fuel around the world for more than 60 years. There are five LPG yard tractors in operation at a terminal in the Port of Los Angeles. Additionally, staff has identified two distribution centers in the Basin that have a combined ten LPG yard tractors in service.

At least one engine manufacturer produces an LPG engine applicable to yard tractors. The 2004 model year engine is certified to a NOx emission limit of 2.5 g/bhp-hr, or 49 % lower than the off-road level of 4.9. g/bhp-hr The PM level is certified at 0.1 g/bhp-hr, or 33% lower than the off-road standard of 0.15 g/bhp-hr.

REPLACEMENT OF OFF-ROAD EQUIPMENT WITH ON-ROAD VEHICLES

The typical useful life of a yard tractor is approximately ten years, though it is often shorter under the heavy use of port operations. Thus, existing off-road engine standards for future model years ensure that yard tractors will get progressively cleaner as the fleets turnover. As discussed in Chapter 1, however, on-road engines are subject to stricter exhaust emission standards than off-road engines. Thus, an effective emission control option would be to replace yard tractors powered by off-road engines with those powered by on-road engines. Yard tractors with on-road certified engines are fully capable of use in “off-road” applications since they are designed under the assumption that they will be used mostly in moving containers around a yard. A number of terminal operators at the Ports of Long Beach and Los Angeles are already in the practice of purchasing yard tractors powered by on-road engines when replacing vehicles in their fleets.

For current model years and up to 2007 models, the NOx and PM emission limits from new on-road engines are approximately 50% and 35% less, respectively, than those for new off-road engines. For 2007 to 2009 models, the NOx and PM emission limits from on-road engines are approximately 60% and 90% less, respectively, than those for off-road engines. Furthermore, the emissions control technologies applicable to yard tractors powered by off-road engines (i.e., DOC and emulsified diesel fuel) are also applicable to on-road engines. Additionally, since most of the efforts to develop mobile source diesel emission control technologies have been directed toward on-road diesel engines, the potential long-term control technologies previously discussed in this chapter may likely be applicable to on-road engines before they are for off-road engine applications. It should be noted that engines meeting 2007 on-road standards are not yet available and manufacturers indicate that integrated systems (e.g., engine plus PM trap and/or NOx control device) may be necessary to meet these standards. However, it is anticipated that engines meeting 2007 on-road standards would be applicable to yard tractors and any potential technical considerations (e.g., impact of off-road duty cycle on integrated systems) would be addressed.

CONCLUSION

Technologies to reduce emissions from off-road engines exist today and continue to develop. These technologies in combination with ultra-low sulfur diesel (<15 parts per million), alternative diesel, and appropriate system integration strategies can be used to significantly reduce emissions from off-road engines. Furthermore, the on-going research and development by manufacturers of emission control equipment is expected to expand the applicability of retrofit technologies to a broader range of engines and applications, including off-road engines/applications. Major considerations for transferring the emission control technologies to off-road applications include exhaust gas temperature and backpressure and ability to integrate them into the wide range of vehicle types. Exhaust gas temperature must be high enough for proper catalyst operation in catalyzed control devices, exhaust backpressure must be minimized to minimize fuel economy penalties, and the system must readily fit in the appropriate place in the exhaust system of the vehicle.

Near-Term Diesel Emission Control Technologies

Diesel emission control technologies that are available today for yard tractors include diesel oxidation catalysts, crankcase emission controls, and emulsified diesel. Additionally, engines powered by alternative fuels (i.e., natural gas, LPG) are available, though yard tractor operators have historically expressed concerns regarding the applicability of alternative fuel equipment to this application because of the power requirements, fuel economy, fueling infrastructure, and reliability under intense operations. New generation alternative fueled vehicles are being commercialized by engine and vehicle manufacturers, however, and the Port of Long Beach and a terminal operator at the Port of Los Angeles will each receive a current model year LNG yard tractor in early 2004 for demonstration purposes.

As discussed above, since on-road engines are subject to stricter exhaust emission standards than off-road engines and yard tractors powered by on-road engines are commercially available, the replacement of yard tractors powered by off-road engines with those powered by on-road engines constitutes a viable near-term diesel emission control technology.

Long-Term Diesel Emission Control Technologies

While important differences do exist, off-road diesel engines operate fundamentally similar to on-road heavy-duty diesel engines, and emission control technologies being developed to meet the 2007 and 2010 heavy duty on-road engines standards can generally be applied to off-road engines and vehicles. Thus, potential diesel emission control technologies which show promise for yard tractor application in the near future include diesel particulate filters, lean NOx catalysts, NOx adsorber catalysts, flow-through-filters, biodiesel, and Fischer-Tropsch fuels.

Table 2-2 presents a summary of the current and potential future diesel emission control technologies applicable to yard tractors, including emission reduction potential, CARB and U.S. EPA emission reductions verification status, technological limitations, and any existing yard tractor applications.

Table 2-2
Emission Control Technology Assessment Summary

CONTROL TECH-NOLOGY	EMISSION REDUCTION RELATIVE TO DIESEL PM	NOx	VERIFICATION/ CERTIFICATION	TECHNOLOGICAL LIMITATIONS	EXISTING YARD TRACTOR APPLICATIONS
Alternative Diesel Fuels					
Emulsified Diesel	58-63% (CARB) 16-58% (EPA)	14-16% (CARB) 9-20% (EPA)	✓ CARB alternative diesel fuel emissions reductions verification ✓ EPA verified product	- 15% fuel penalty - Increased CO emissions (~5%) Increased HC emissions Possible separation of water and fuel if unused over 30 days	Yes. Currently being used at the Ports of Los Angeles and Long Beach.
Biodiesel (B20)	10%	+2%	No	- 1-2% fuel penalty (B20) - Increased NOx emissions - Higher gelling temperature than petrodiesel (can clog fuel filters/lines in cold weather– more of an issue for B100)	No
Ethanol Diesel	20%	2%	✓ CARB alternative diesel fuel emissions reductions verification	- Increased CO, HC, aldehyde emissions - Safety (esp. flammability concerns - Engine manufacturers recommend against use in their products	No
Fischer-Tropsch Fuels	24%	12%	No	- Expensive to produce on large-scale at present time	No
Retrofit Technology					
Diesel Oxidation Catalyst	$\geq$25 - <50% (CARB) 25-33% (EPA)	--	✓ CARB DECS Level 1: off-road and on-road ✓ EPA verified product: on-road only (combined DOC/crankcase control system)	- Requires low sulfur fuel (<15ppm)	Yes. Currently being used at the Ports of Los Angeles and Long Beach.

DECS = diesel emission control strategy

Table 2-2 (continued)
Emission Control Technology Assessment Summary

CONTROL TECH-NOLOGY	EMISSION REDUCTION RELATIVE TO DIESEL		VERIFICATION/ CERTIFICATION	TECHNOLOGICAL LIMITATIONS	EXISTING YARD TRACTOR APPLICATIONS
	PM	NOx			
Retrofit Technology (continued)					
Diesel Particulate Filter	≥85% (CARB) 60-90% (EPA)	--	✓ CARB DECS Level 3: on-road only ✓ EPA verified product: on-road only	- Active regeneration technology required to expand to off-road applicability	No
Flow-Through-Filter	30-60%	--	No	- No CARB verified product - Filtration efficiency lower than DPF - Increased backpressure relative to DOC	No
Lean NOx Catalyst	--	10-20%	No	- No CARB verified product - Durability issues (especially against sulfur poisoning) - Narrow operating temperatures	No
NOx Adsorber	--	up to 90	No	- No CARB verified products - Diesel fuel <15 ppm sulfur essential - 3% fuel penalty - Engine controls required to modulate diesel engines between rich and lean operation and to allow for desulfurization	No

DECS = diesel emission control strategy

Table 2-2 (continued)
Emission Control Technology Assessment Summary

CONTROL TECH-NOLOGY	EMISSION REDUCTION RELATIVE TO DIESEL		VERIFICATION/ CERTIFICATION	TECHNOLOGICAL LIMITATIONS	EXISTING YARD TRACTOR APPLICATIONS
	PM	NOx			
Alternative Fuels					
CNG	33%	63%	CARB certified engine	- Fuel penalty (71%) - Fueling infrastructure	Yes. At least 17 in service at distribution center in Oregon. None known to be in use locally.
LNG	33%	63%	CARB certified engine	- Fuel penalty (43%) - Fueling infrastructure (cryogenic nature of LNG, unique storage vessel requirements, limited liquid hold time)	Yes. Two in service at distribution center in Sacramento. None known to be in use locally. Two independent demonstration projects at Ports in 2004.
LPG	33%	49%	CARB certified engine	- Fuel penalty (35%) - Fueling infrastructure/operations (pressurized both inside vehicle and in storage tanks)	Yes. 15 total known to be in service at Port of Los Angeles and distribution centers.
On-Road Certified Engines					
Engines Certified to On-Road Emission Standards	50% (comparing model year 2004 engines certified to applicable off-road and on-road standards)	50% (comparing model year 2004 engines certified to applicable off-road and on-road standards)	CARB certified engine	- Possible technical limitations of engine systems meeting 2007 on-road standards to yard tractors due to duty-cycle (e.g., temperatures may not be sufficient for PM traps if traps are passive type)	Yes. At least one terminal operator has policy to exclusively purchase yard tractors powered by on-road engines. Other operators include tractors with on-road certified engines in their fleets.

INTRODUCTION

The primary pollutants of concern from diesel engines are NOx and PM. The high combustion and exhaust temperatures and excess air cause the nitrogen in the air to combine with available oxygen to form NOx. In addition to the PM emissions resulting from incomplete combustion of fuel, lubrication oil entering the cylinder contributes to overall PM emissions. Since diesel-cycle combustion operates with excess air, by-products due to incomplete combustion, including HC and CO, are emitted at relatively low levels.

EMISSION REDUCTIONS AND COST-EFFECTIVENESS

Both baseline and controlled PM and NOx emissions have been estimated for a typical yard tractor powered by (1) an uncontrolled (pre-1996) off-road engine, (2) a Tier 1 (1996-2002) off-road engine, (3) a Tier 2 (2003-2006) off-road engine, and (3) a Tier 3 (2006+) off-road engine. The controlled PM and NOx emissions are for the CARB verified diesel emission control technologies, on-road engines, and alternative fuels discussed in Chapter 2. The estimated cost-effectiveness of these technologies for combined NOx and PM reductions have been calculated based on available cost data[9]. Summaries of the baseline emissions, emission reductions, and cost-effectiveness data is presented in Table 3-1, Table 3-2, and Table 3-3, respectively.

Table 3-1
Baseline Emissions From Off-Road Engines Used in Yard Tractors

Off-Road Engine Emission Factor (g/hp-hr)	Uncontrolled Engine (pre-1996) NOx = 8.14 PM = 0.38		Tier 1 Engine (1996-2002) NOx = 6.9 PM = 0.38		Tier 2 Engine (2003-2006) NOx+NMHC = 4.9 PM = 0.15		Tier 3 Engine (2006+) NOx = 3.0 PM = 0.15	
Pollutant	NOx	PM	NOx	PM	NOx	PM	NOx	PM
Baseline Emissions Per Vehicle (lbs/yr)	4,350	170	3,400	190	2,290	80	1,410	80

See Table 3-2 for emissions calculation assumptions.

[9] Note: the cost-effectiveness calculations for CNG, LNG, and LPG do not include the costs associated with fueling infrastructure construction and operation.

Table 3-2
Emission Reduction Summary - CARB Verified Diesel Emission Control Technologies, On-Road Engines, and Alternative Fuels

	Baseline Engine							
	Uncontrolled Engine (pre-1996)		Tier 1 Engine (1996-2002)		Tier 2 Engine (2003-2006)		Tier 3 Engine (2006+)	
	Emission Reductions Per Vehicle (lbs/yr) (% Reduction from Baseline) *							
Control Technology	**NOx**	**PM**	**NOx**	**PM**	**NOx**	**PM**	**NOx**	**PM**
Emulsified Diesel (ED)	650 (15%)	100 (60%)	510 (15%)	120 (60%)	344 (15%)	50 (60%)	210 (15%)	50 (60%)
Diesel Oxidation Catalyst (DOC)	0 (0%)	40 (25%)	0 (0%)	50 (25%)	0 (0%)	20 (25%)	0 (0%)	20 (25%)
Emulsified Diesel + DOC	650 (15%)	140 (84%)	510 (15%)	160 (84%)	340 (15%)	60 (84%)	210 (15%)	60 (84%)
2004 On-Road Engine Std.	3,180 (73%)	120 (70%)	2,230 (66%)	140 (74%)	1,120 (49%)	30 (33%)	240 (17%)	30 (33%)
2004 On-Road Engine Std.+ ED	3,360 (77%)	150 (88%)	2,410 (71%)	170 (90%)	1,300 (57%)	60 (77%)	410 (29%)	60 (73%)
2004 On-Road Engine Std. + DOC	3,180 (73%)	130 (78%)	2,230 (66%)	160 (80%)	1,120 (49%)	38 (50%)	240 (17%)	40 (50%)
2004 On-Road Engine Std. + ED + DOC	3,360 (77%)	160 (95%)	2,410 (71%)	190 (96%)	1,300 (57%)	70 (89%)	410 (29%)	70 (89%)
2007 On-Road Engine Std.	3,670 (84%)	170 (97%)	2,720 (80%)	190 (97%)	1,610 (70%)	70 (92%)	730 (52%)	70 (92%)
LNG	3,530 (81%)	160 (90%)	2,590 (76%)	180 (91%)	1,480 (64%)	60 (78%)	730 (52%)	70 (92%)
CNG	3,530 (81%)	160 (90%)	2,590 (76%)	180 (91%)	1,480 (64%)	60 (78%)	730 (52%)	70 (92%)
LPG	3,220 (74%)	120 (67%)	2,270 (67%)	140 (71%)	1,160 (51%)	20 (25%)	730 (52%)	70 (92%)

* Emission reductions may not represent exact percent reduction from baseline due to rounding.

Assumptions for emission reductions calculations in Table 3-2:

- Uncontrolled (pre-1996) baseline emission factors from Carl Moyer Program Guidelines Table 3.5
- Tier 1, Tier 2, and Tier 3 emission factors = off-road engine standards
- NOx fraction default values (of NOx+NMHC emission standard) from Carl Moyer Program Guidelines Table 3.2
- Default load factor = 0.57 (adjusted for power rating differences for on-road, natural gas, and LPG engines) (Source: 2003 Baseline Emission Inventory, POLB)
- Fuel correction factors for pre-2007 diesel engines from Carl Moyer Program Guidelines Table 2.9 (on-road engines) and Table 3.7 (off-road engines)
- DOC is a combination DOC with closed crankcase filtration system. Assumes the lower end of the CARB Level 1 Verified Technology PM emission reduction range (25 - 49%)
- Assumes emulsified diesel + DOC system will receive a Level 2 Verification. Assumes high end of Level 2 (i.e. 84% PM reduction)
- 2004 model year on-road and LPG engines meet 2004 on-road diesel engine standards of 2.5 g/hp-hr NOx+NMHC and 0.1 g/hp-hr PM
- 2007 model year on-road, CNG/LNG, and LPG engines meet emission standards of 1.2 g/hp-hr NOx and 0.01 g/hp-hr PM
- 2004 model year CNG/LNG engines meet optional low-NOx standard of 1.8 g/hp-hr NOx+NMHC and 0.03 g/hp-hr PM;
- Baseline off-road engine = 188 hp
- On-road engine = 215 hp
- LNG/CNG engine = 230 hp
- LPG engine = 195 hp
- Hours of operation = 2,400 hours per year

Table 3-3
Cost-Effectiveness Summary - CARB Verified Diesel Emission Control Technologies, On-Road Engines, and Alternative Fuels

	Baseline Engines			
	Uncontrolled (pre-1996)	Tier 1 (1996-2002)	Tier 2 (2003-2006)	Tier 3 (2006+)
Control Technology	**Cost Effectiveness NOx+PM ($ / ton)**			
Emulsified Diesel (ED)	$14,600	$17,600	$28,200	$42,900
Diesel Oxidation Catalyst (DOC)	$12,700	$11,300	$28,800	$28,800
Emulsified Diesel + DOC	$14,500	$17,200	$28,300	$42,100
2004 On-Rd. Engine	$200	$300	$700	$3,100
2004 On-Rd. Engine + ED	$3,400	$4,600	$8,700	$25,300
2004 On-Rd. Engine + DOC	$400	$600	$1,200	$5,000
2004 On-Rd. Engine + ED + DOC	$3,500	$4,800	$9,000	$25,800
2007 On-Rd. Engine[1]	$200	$300	$500	$1,000
LNG[1, 2]	$6,500	$8,700	$15,600	$30,100
CNG[1, 2]	$8,700	$11,700	$21,000	$40,500
LPG[1, 2]	$8,800	$12,200	$24,900	$37,000

[1] Assumes no price change relative to 2004 model year vehicles.
[2] Does not include the costs associated with fueling infrastructure construction and operation.

Assumptions for cost-effectiveness calculations in Table 3-3

- Off-road yard tractor purchase price = $60,000
- On-road yard tractor purchase price = $64,000
- LNG yard tractor purchase price = $93,000
- CNG yard tractor purchase price = $93,000
- LPG yard tractor purchase price = $89,000
- DOC cost = $1,500 per unit (assumes 2 DOCs needed over 10 year vehicle life; present worth factor for second DOC unit = 0.8219@4% real interest for 5 years)
- Diesel fuel cost = $1.72 per gallon (retail)
- Emulsified diesel fuel = $1.97 per gallon (retail)
- CNG = $1.67 per gallon (retail)
- LNG = $1.74 per gallon (retail)
- LPG = $2.05 per gallon (retail)
- Hours of operation = 2,400 hours per year
- Energy consumption factor = 18.5 hp-hr (Carl Moyer Program Guidelines)
- Fuel penalty = 15% for emulsified diesel, 43% for LNG, 71% for CNG, and 35% for LPG
- Equipment life = 10 years
- Present worth factor = 8.111@4% real interest for 10 years

CONCLUSION

Based on this feasibility study, all the technologies analyzed provide cost-effective control strategies for NOx and PM for uncontrolled (pre-1996) off-road engines. As can be seen from the data in Table 3-3, the most cost-effective approach for uncontrolled as well as later model off-road engines is the use of yard tractors powered by on-road certified engines.

In general, the other technologies analyzed have higher cost-effectiveness because they either provide only modest emission reductions compared to on-road engines, or have comparatively higher costs associated with them. For example, while the capital cost of diesel oxidation catalysts is quite low, the cost-effectiveness of this technology is comparatively high especially relative to later model year off-road engines since it provides only modest PM10 emission reductions and does not reduce NOx emissions. Conversely, emulsified diesel fuel provides substantial PM10 reductions, but is fairly expensive relative to petrodiesel at current prices and thus also has a comparatively high cost-effectiveness. It may be reasonably assumed, however, that increased production of emulsified diesel would result in a reduction in price and improved cost-effectiveness. Additionally, while DOCs and emulsified diesel both have comparatively high cost-effectiveness, these retrofit technologies may be part of an effective control strategy for reducing emissions from yard tractors due to ease of use, low or no capital costs, minimal maintenance requirements, etc. Furthermore, in combination with on-road engines, both DOCs and emulsified diesel fuel provide substantial and highly cost-effective emission reductions.

Vehicles powered by alternative fuels (i.e., natural gas, LPG) provide substantial reductions but at a comparatively high cost-effectiveness relative to later model year off-road vehicles (even without consideration of fueling infrastructure costs) due to the high capital costs of vehicles (at current price points) as well as the high annual costs due to fuel penalties compared to conventional diesel vehicles. Nevertheless, the use of alternative fueled yard tractors may be part of an effective strategy to control emissions from yard tractor fleets, especially for those yard tractor operators using alternative fueled vehicles in their existing operations (e.g., LPG forklifts, CNG trucks, etc.). As with other control technologies, as alternative fuel vehicle technologies mature, the cost-effectiveness of these technologies will likely improve.

INTRODUCTION

This chapter presents a number of possible regulatory approaches to control emissions from yard tractors used by terminal operators within the local ports. These possible control strategies will require further development to account for technical, cost, and legal considerations. Consideration of the possible regulatory approaches can be viewed in the context of AQMD authority to control emissions of criteria pollutants (i.e., NOx, PM) and/or toxic air contaminants (i.e., diesel particulate).

FLEET RULE APPROACH

Similar to the AQMD's existing fleet rules, this regulatory approach assumes that yard tractors would be treated as fleets of vehicles and that new vehicle purchases must have emissions equivalent to alternative clean fuels.

Control Concept

Under this regulatory approach, any new purchases of off-road and on-road type yard tractors will be required to be powered by alternative clean fuels such as LNG/CNG, LPG, or any other alternative fuel which meets the equivalency criteria allowed under Health and Safety Code §40447.5. The Los Angeles Board of Harbor Commissioners recently adopted a Clean Engines and Fuels Program (a non-binding commitment by the Port) to incorporate, where operationally feasible, alternative clean fuel vehicles into its fleet as its conventionally-powered vehicles are retired. Additionally, as part of the China Shipping settlement agreement between community groups and the Port of Los Angeles (see Chapter 1), all of the yard tractors used at the China Shipping terminal will run on alternative clean fuels.

It should be noted that yard tractor operators have historically expressed concerns regarding the applicability of alternative clean fuel equipment to this application because of power requirements, fuel economy, fueling infrastructure, and reliability under intense operations. Thus, as part of rule development under a fleet rule approach, staff would address any potential technical issues associated with alternative clean fuel powered yard tractors.

Legislative Authority and Other Considerations

Under State law, the AQMD has the authority to require public and commercial fleet operators to purchase clean burning alternative fuels when replacing vehicles in their fleet. Health and Safety Code § 40447.5(a) specifically allows the AQMD Board to adopt regulations that:

> Require operators of public and commercial fleet vehicles, consisting of 15 or more vehicles under a single owner or lessee and operating substantially in the south coast district, when adding vehicles to or replacing vehicles in an existing fleet or purchasing vehicles to form a new fleet, to purchase vehicles which are capable of operating on methanol or other equivalently clean burning alternative fuel and to require that these vehicles be operated, to the

> maximum extent feasible, on the alternative fuel when operating in the south coast district . . .

Though a large percentage of the existing yard tractor fleets operated at the ports are powered by off-road engines and are not licensed for use on streets or highways (i.e., not DOT-certified), they are considered motor vehicles under State law. Section 415 of the Vehicle Code defines motor vehicles as vehicles designed to be capable of transporting people or goods on streets or highways. "Capable" means physically able - not legally operable - for such use. Consequently, a fleet vehicle rule is a viable option for this source.

While the AQMD has the regulatory authority to adopt a fleet rule for yard tractors, there is a reason that such an approach may not be the preferred control strategy at this time. Specifically, the U.S. Supreme Court recently heard arguments challenging the legality of AQMD's existing fleet rules (case No. 02-1343). Developing a fleet rule for yard tractors prior to the Court's decision may raise regulatory uncertainty concerns during rule development.

INDIRECT SOURCE APPROACH

Under this approach port terminals are classified as indirect sources subject to AQMD authority to regulate such sources.

Control Concept

Under this approach, staff would develop a rule that reduces emissions from yard tractors based on use restrictions (i.e., hours of operation or fuel use). It should be noted that the purpose of the program is not to limit growth at the ports, but to reduce emissions. Potential strategies would be designed in such a way that dirtier engines would be subject to more severe use restrictions with incentives provided to accelerate engine replacement. The operating hours or fuel use limits would be based on an evaluation of feasible reductions.

As part of rule development, staff would consider including alternative compliance options that achieve reductions equivalent to those achieved by the required operational restrictions. Such alternative compliance options may include a fleet average emission rate (including use of vehicles powered by on-road certified engines, retrofit technology, alternative fuels, etc.), purchase/retirement requirements, operational improvements, alternative fuels option, or a mitigation fee.

Legislative Authority and Other Considerations

While local and regional authorities have the primary responsibility for control of air pollution from all sources other than emissions from motor vehicles, the California Health and Safety Code provides AQMD with two types of authority relative to motor vehicles – fleet rule authority (see above) and indirect source authority. Health and Safety Code § 40716(a)(1) authorizes the AQMD reduce or mitigate emissions from indirect sources. Additionally, Health and Safety Code § 40440(b)(3) sets forth that the AQMD adopt rules and regulations to carry out the Air Quality Management Plan including those that provide for indirect source controls in those areas of the South Coast district in which there are high-level, localized concentrations of pollutants or with respect to any new source that will have a significant effect on air quality in the South Coast Air Basin. This indirect source provision provides broad authority to the AQMD in controlling indirect sources allowing for a range of possible compliance strategies such as use limits (e.g., hours of operation, trip numbers or length, etc.), mitigation fee, or an emissions cap. Consequently, a control approach based on AQMD's indirect source authority appears to provide a viable option for reducing emissions (criteria or toxics) from yard tractors.

RETROFIT CONTROL APPROACH

Under this approach, AQMD would establish retrofit requirements for existing yard tractor fleets based on verified retrofit technologies or replacement of existing off-road engines with cleaner engines.

Control Concept

Under a retrofit control approach, any retrofit technology would have to be certified by CARB through the Diesel Emission Control Strategy Verification Procedure. AQMD would establish emission reduction requirements (i.e., by vehicle or by fleet average) based on CARB's verified levels of reductions for retrofit technologies. Proven diesel emission control technologies that are commercially available for on-road diesel engines include diesel oxidation catalysts, diesel particulate filters, engine adjustments, emulsified fuels, and integrated systems that combine these technologies. Proven technologies for off-road engines include diesel oxidation catalysts, emulsified diesel, and alternative fuels.

As previously discussed, the Ports of Los Angeles and Long Beach have both initiated voluntary diesel emission reduction programs which encourage the use of retrofit controls on yard tractors and other off-road equipment. The Ports have made funds available to their tenants (i.e., terminal operators) to help subsidize the costs of retrofit technologies, including emulsified diesel fuel and diesel oxidation catalysts.

Legislative Authority and Other Considerations

State law grants CARB the authority to set standards for motor vehicles, including off-road equipment meeting the definition of "vehicle" (see discussion under Fleet Rule Approach, above). Air districts are not authorized to control motor vehicles (Health and Safety Code § 39002). Thus, AQMD has no authority to establish direct standards. To require a retrofit strategy, AQMD would have to obtain additional authority. For example, state law could be amended to authorize AQMD to develop and adopt retrofit standards. These standards, once adopted as AQMD regulations, would be submitted for CARB's approval as "California standards" which would then be subsequently submitted for EPA's approval. If CARB were to submit the "California standards" to U.S. EPA, U.S. EPA would still have to authorize the retrofit rule prior to the rule taking effect. However, because of the uncertainty in obtaining such authority, this approach is not recommended at this time.

AIR TOXICS REDUCTION APPROACH

This approach would seek to control emissions of toxic air contaminants (i.e., diesel particulates) from existing yard tractor fleets.

Control Concept

Under this approach, terminal operators would be required to reduce emissions of toxic air contaminants from yards tractors. Since the main toxic component of yard tractor emissions is diesel particulates, this approach would focus on controlling emissions of diesel PM.

Legislative Authority and Other Considerations

California Health and Safety Code § 39656 sets forth the intent of the Legislature that the state board and the districts implement a program to regulate toxic air contaminants that will enable the state to receive approval to implement and enforce emission standards and other requirements for air pollutants subject to Section 112 of the federal Clean Air Act. Under this authority, AQMD has adopted a number of rules controlling emissions of toxic air contaminants for stationary sources.

To control air toxic emissions from yard tractors, the AQMD could use its toxic control source authority in conjunction with its indirect source authority to regulate diesel particulate emissions from this source category. Therefore, this control approach would be similar to the indirect source approach discussed earlier.

RECOMMENDED CONTROL APPROACH

Based on the analysis in this White Paper, staff recommends pursuing an indirect source rule approach, including air toxics considerations, for reducing emissions from yard tractors. Under this approach, staff would develop an indirect source rule, using its indirect source and air toxics statutory authority, which would establish use restrictions (e.g., hours of operation, fuel consumption) for yard tractors operated at ports. As part of rule development, staff would also consider including alternative compliance options such as a fleet average emission rate, purchase/retirement requirements, operational improvements, alternative fuels option, or a mitigation fee. In addition, depending on the outcome of the Supreme Court case concerning AQMD's fleet rules, further requirements may be considered pursuant to AQMD's state authorized fleet authority. Following the release of this White Paper, staff will proceed with rule development in conjunction with all stakeholders. The next phase of rulemaking will be developed for yard tractors operated at rail yards and distribution centers.

ACTION PLAN

Staff presented the concepts set forth in this White Paper to AQMD's Mobile Source Committee on February 27, 2004, whose members concurred with staff's recommendation to proceed with rule development commensurate with AQMD's authority. The Committee requested that staff engage air pollution control staff in other areas of the country with high concentrations of yard tractors to facilitate a market for cleaner vehicles, and to ensure port administrators (including the Harbor Commissioners) and equipment manufacturers are included during rule development. Accordingly, staff will initiate the rule development process by releasing the draft White Paper, establishing a stakeholders working group, and developing specific rule requirements.

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