CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
AIR RESOURCES BOARD

STAFF REPORT: INITIAL STATEMENT OF REASONS FOR PROPOSED RULEMAKING, PUBLIC HEARING TO CONSIDER ADOPTION OF EMISSION STANDARDS AND TEST PROCEDURES FOR NEW 2007 AND LATER OFF-ROAD LARGE SPARK-IGNITION (LSI) ENGINES AND FLEET REQUIREMENTS FOR USERS OF OFF-ROAD LSI ENGINES

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EXECUTIVE SUMMARY

Air quality in California has improved dramatically over the past 30 years, due in large part to the continued progress in controlling pollution from mobile sources. Despite the achievements to date, many parts of the state still do not meet state or federal health-based ambient air quality standards. More people are driving, and those same people are driving more miles – ozone/smog is still a serious problem. Clearly, all sources of pollution must be addressed and controlled if California is going to meet and sustain its air quality goals.

In 1998 the California Air Resources Board (ARB or Board) first adopted emission standards for large spark ignition (LSI) engines of 25 horsepower or larger. These engines are used in off-road equipment including forklifts, airport ground support equipment, sweepers, and scrubbers. The full implementation of the emission standards in 2004 successfully required engine manufacturers and a variety of equipment that run on gasoline or propane to apply control technologies and strategies for light-duty on-road vehicles to engines in this category. As a result of the new standards, emissions from new engines were reduced by approximately 75 percent.

Building on this success, the United State Environmental Protection Agency (U.S. EPA) harmonized with California's standards and adopted more stringent requirements for new engines produced for the 2007 and later model years. The federal program demonstrated that additional reductions were technically feasible and cost-effective.

In evaluating the federal program, the state of technology, and the commitments made by the ARB within the 2003 State Implementation Plan for Ozone, ARB staff determined that further reductions from new and from in-use engines were achievable and necessary. Consequently, the ARB staff began the proposed rulemaking in 2004 to develop new requirements that would ultimately include new engine certification engine standards for equipment manufacturers and in-use fleet-average requirements for users of the equipment. The key elements of the proposal include:

Requirements for Engine Manufacturers

- Alignment with the engine certification standards adopted by the U.S. EPA beginning in 2007.
- Alignment with additional requirements of the federal rule including more vigorous test procedures and on board diagnostics.
- More stringent emissions standards for 2010 and later based on control technologies needed to meet the standard for 2007 but optimized to reduce hydrocarbon (HC) and oxides of nitrogen (NOx) emissions.

- Optional lower-emission standards that allow engine manufacturers to provide additional value to fleet users.

Requirements for Fleet Users

- Fleet average requirements for operators of specific LSI equipment: forklifts, sweeper/scrubbers, industrial tow tractors and airport ground support equipment.

- The operator is provided the flexibility to use a combination of retrofits, lower-emission purchases, and zero-emission electric purchases to meet the fleet average emission level beginning January 2009 and becoming progressively more stringent over time.

- An alternative compliance option for agricultural fleets to address issues specific to this industry.

Verification Procedure for Manufacturers of Retrofit Emission Control Systems

- A new procedure for verifying LSI retrofit emission control systems to address emissions from existing engines, consistent with adopted requirements for diesel retrofit systems.

Economic and Environmental Impacts

The proposed 2007 emission standards for engine manufacturers are not expected to create significant economic impacts as manufacturers are already developing engines to comply with the federal 2007 standards. The proposed standards for 2010 and later leverage work already being done to meet the federal program and thus provide extremely cost effective emission reductions of $0.13 per pound.

The proposed fleet standards will require operators to procure low- and zero-emission equipment and address uncontrolled equipment within their fleets. The use of compliant new engines and the retrofit of existing engines have been shown to reduce fuel use and improve engine life, thus creating cost savings for equipment users making the fleet standards also extremely cost effective. The cost-effectiveness ranges from $0.13 per pound for lower-emission equipment to $1.40 per pound for electric equipment. The proposed implementation date of January 2009 will provide time and flexibility to fleet operators as they work to comply with the standards.

The primary benefits of the proposed regulation will be a reduction in smog-forming pollutants to Californians. The ARB staff projects that the application of control systems to both existing and new engines will reduce hydrocarbon and oxides of nitrogen emissions by more than 13 tons per day in 2010 and 6 tons per day in 2020.

Staff Recommendation

The ARB staff recommends that the Board adopt the amendments and additions as proposed in this Initial Statement of Reasons. The proposed amendments provide significant flexibility to fleet users while addressing the highest-polluting equipment up front and putting in place cleaner engine standards for the longer term. The amendments meet ARB's commitments contained in the 2003 State Implementation Plan for Ozone and provide cost-effective emission reductions from both new and existing engines.

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1 INTRODUCTION

The California Clean Air Act (CCAA) as codified in the Health and Safety Code sections 43013 and 43018 grants the Air Resources Board (ARB) authority to regulate off-road mobile sources of emissions. These sources include, but are not limited to marine vessels, locomotives, utility engines, off-road motorcycles, and off-highway vehicles. Off-road large spark-ignition (LSI) engines are a subcategory of off-road engines subject to ARB regulation. The ARB estimates that there are approximately 88,000 LSI engines in 2004. Statewide hydrocarbon (HC) and oxides of nitrogen (NOx) emissions from LSI equipment are approximately 15 and 54 tons per day, respectively. Forklifts represent almost half of the LSI engine population and more than 85 percent of the HC+NOx emissions.

Typical applications for off-road LSI engines include forklifts, portable generators, large turf care equipment, irrigation pumps, welders, air compressors, scrubber/sweepers, airport service vehicles, and a wide array of other agricultural, construction and general industrial equipment. The engines used are typically derived from automobile engines, and are most commonly fueled by gasoline or liquefied petroleum gas (LPG).

The ARB first adopted emission standards for off-road LSI equipment over 25 horsepower (19 kilowatts) in 1998, with implementation beginning in the 2001 model year. The proposed amendments contained within this rulemaking continue the ARB's efforts to achieve the greatest cost-effective reductions possible from the category. The proposal would harmonize ARB's new engine emission standards to the federal program in 2007 and establish more stringent new engine emission standards in 2010. The proposal would also allow optional lower-emission standards and establish new requirements for operators to accelerate the introduction of cleaner engines and provide a procedure for certifying retrofit systems for engines already in-use.

1.1 Overview

This report presents the proposed regulation to further reduce HC+NOx emissions from off-road equipment with LSI engines of 25 horsepower or more (greater than 19 kilowatts). A summary of the requirements of the proposal is presented in Section 3 of the Staff Report.

This report also provides the information that ARB staff used to develop the proposal. This information includes:

- Current and pending requirements to reduce emissions from off-road LSI engines;
- Current emission inventory and operational characteristics of off-road LSI engines;
- A summary of the proposed regulation including a discussion of applicability, proposed requirements, and record keeping and reporting requirements;
- A summary of compliance options, including a discussion of available zero- and lower-emission technologies and compliance scenarios;

- A discussion of the environmental and economic impacts of implementing the proposal; and
- Additional considerations.

The regulatory text and other supporting information for the various elements of the proposal are found in the Appendices.

The manufacturer lower-emission standards will ensure that all new LSI engines and equipment achieve the most cost-effective emissions reductions possible. The operational requirements will ensure that users, owners, and operators of both new and in-use off-road LSI equipment reduce overall emissions to the maximum extent possible. Operational requirements are the fleet average emission level established for large and mid-size fleets, the proposed annual requirements established for fleets used in agricultural crop preparation services, and the requirement that small fleets address their uncontrolled equipment. Finally, record keeping and reporting requirements provide the ARB staff the ability to ensure compliance with the fleet average or draw down provisions of the regulation, while the labeling requirements provide operators with labeling information for determining compliance with their fleet average provisions.

In developing the proposal, there were a number of technical and policy issues that had to be addressed. These included defining a test method for verifying retrofit emissions, early new engine certification and retrofit emission control system verification procedures, and harmonization with federal LSI requirements developed by the United States Environmental Protection Agency (U.S. EPA). Additional issues are discussed in Section 9, Additional Considerations.

1.2 Regulatory Authority

The CCAA grants the ARB authority to regulate off-road mobile sources of emissions. These mobile sources include, but are not limited to marine vessels, locomotives, utility engines, off-road motorcycles, and off-highway vehicles. Off-road large spark-ignition engines are a subcategory of off-road engines subject to ARB regulation. The proposal addresses new and non-new off-road LSI equipment greater than 25 horsepower (19 kilowatts) for which California retains regulatory authority. Off-road LSI equipment with engines greater than 25 horsepower, but a displacement of less than one liter, are not included as part of this proposal.

The proposal does not address new equipment under 175 horsepower used primarily in farm equipment or vehicles and in construction equipment or vehicles as the U.S. EPA has sole authority to control emissions from this equipment. U.S. EPA's authority is based on federal Clean Air Act section 209(e)(1)(A) which preempts states from adopting or enforcing any standard or other requirement relating to the control of emissions of new engines in these categories. Because of this preemption, significant emissions from the subject engine category are beyond ARB's authority to regulate. However, as discussed in the summary of existing federal regulations in Section 2.2, the

ARB staff worked closely with the U.S. EPA in their development of a nationwide federal rule to cover all engines in this category.

To define the scope of the preemption, U.S. EPA adopted regulations at title 40, Code of Federal Regulations, section 85.1601, et seq. The federal regulations provide that a given type of equipment is treated as farm equipment if the equipment is "primarily used in the commercial production and/or commercial harvesting of food, fiber, wood, or commercial organic products or for the processing of such products for further use on the farm." A similar determination of primary use is applied for construction equipment, defined as equipment used in construction and located on commercial construction sites.

To further identify preempted equipment, ARB established a list of the types of equipment that did or did not constitute construction or farm equipment based on U.S. EPA regulations and discussions with various trade organizations. For equipment over 25 horsepower, all equipment was considered to be construction or farm equipment except for the 11 categories listed below. In ARB's initial 1998/1999 rulemaking to establish standards for large spark-ignition engines, the non-preempted types were refined and specified as:

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

1.3 Applicability

The manufacturer lower-emission standards presented in Section 3.1 apply to engines greater than 25 horsepower used predominantly in the 11 categories of equipment listed above, just as the standards in the original LSI rule did. However, the proposed standards do not address the component of these engines with a displacement of less than or equal to 1 liter. This is a change from the original LSI rule, which established two sets of new engine emission standards – one for engines with a displacement greater than 1 liter, and one for engines with a displacement of less than or equal to 1 liter. The change reflects a feature of the U.S. EPA regulatory language for their Class II engines (less than 19 kW): when the U.S. EPA sets new standards for these engines, the same standards automatically apply to engines greater than 19 kW, but with a displacement of less than 1 liter. The U.S. EPA plans to propose new standards for their Class II engines by the end of this year that are significantly lower than the current standards.

The fleet average emission level proposal (fleet average) presented in Section 3.2 applies to airport ground support equipment (GSE). Examples of GSE include forklifts, tugs, belt loaders, bobtails, cargo loaders, lifts, air conditioner, service trucks, de-icers, fuel delivery trucks, and ground power units. The fleet average also applies to sweeper/scrubbers, non-GSE forklifts, and non-GSE industrial tow tractors.

However, most, and possibly all GSE in the South Coast Air Basin would be exempt from the in-use requirements of this proposal through 2010 because their emissions are already addressed in a 2002 Memorandum of Understanding (MOU) between the ARB and the basin's airlines (GSE MOU, 2002). Staff is proposing that GSE in the South Coast Air Basin be phased into this regulation following expiration of the MOU. Any extension of the MOU or development of a similar agreement signed by the ARB to other locations within California could preempt the GSE fleet requirements of this proposal as well.

Additionally, 46 percent of the engines that were certified in the 2004 model year for sweeper/scrubber applications had a displacement of one liter or less (ARB, 2005a). These engines would not be subject to this proposal.

Diesel equipment, including diesel forklifts, would not be subject to the requirements of this proposal as the ARB typically regulates diesel or compression ignition engines separately from LSI engines. This is in part due to the different pollutants and measuring techniques. However, the particulate emissions from diesel-fueled engines have been identified as a toxic air contaminant (TAC). TACs are those air pollutants that may cause or contribute to an increase in death or serious illness or may pose a present or future hazard to human health. Consequently, the ARB is separately controlling emissions from diesel-fueled applications in an expedited timeframe, typically by establishing state-of-the-art technology requirements (e.g., a requirement to retrofit diesel engines with particulate filters). Proposed requirements for in-use diesel forklifts are expected in late 2005.

1.4 Air Quality Needs and the Emissions from LSI

The ARB is responsible for protecting public health and the environment in California from the harmful effects of air pollution. To carry out this responsibility, the ARB establishes health-based ambient air quality standards. These standards identify outdoor pollutant levels that are considered safe for the public – including those most sensitive to the effects of air pollution, such as children and the elderly. The ARB has set standards for eight criteria pollutants, including ozone. The ARB then works in cooperation with 35 local air districts and the U.S. EPA on strategies to attain the State and federal standards. Despite significant success in reducing overall pollution levels, air pollution continues to be an important public health problem. Air monitoring shows that over 90 percent of Californians breathe unhealthy levels of one or more air pollutants during some part of the year.

1.4.1 Health Impacts of Exposure to Ozone

The proposed regulation will reduce the public's exposure to ground-level ozone by reducing NOx and HC emissions, which are precursors to the formation of ozone in the lower atmosphere. Ozone, an important ingredient of smog, is a highly reactive and unstable gas. Symptoms of ozone exposure include coughing, chest tightness, shortness of breath, and the worsening of asthma symptoms. Repeated exposure to ozone can make people more susceptible to respiratory infection, lung inflammation and tissue damage, and can aggravate preexisting respiratory diseases, such as asthma. It can damage the respiratory tract, causing inflammation and irritation, which can result in breathing difficulties.

Currently, the state's strategies for reducing emissions from all sources are contained within the State Implementation Plans or SIPs. The SIPs establish blueprints for California's efforts to achieve attainment of ambient ozone and particulate matter standards throughout the state. LSI emission reductions are part of both the ARB's ozone and particulate matter SIPs.

2 CURRENT REGULATIONS AND INVENTORY

2.1 California LSI Regulation

In 1998 the ARB adopted LSI regulations that addressed the state's obligations under the 1994 Ozone SIP. The regulations represented the first part of a collective effort by the ARB and the U.S. EPA to work together to develop a harmonized national program. The regulations required new LSI engines sold in California to be certified to a standard of 3.0 g/bhp-hr of HC+NOx phased in from 2001 to 2004.

2.2 Federal LSI Regulation

As mentioned in the discussion of regulatory authority, the federal Clean Air Act Amendments of 1990 preempt California from controlling emissions from farm and construction equipment under 175 horsepower. To ensure that this preemption did not result in significant levels of unaddressed emissions from the subject engine category, the ARB staff worked closely with the U.S. EPA in their development of a nationwide federal rule to cover all engines in this category.

The federal rule, which addressed the obligations of the California SIP for ozone, was finalized in 2002 (U.S. EPA, 2002). It regulated emissions from farm and construction equipment in California in the absence of ARB's authority to do so. The federal rule and California's 1998 regulations were harmonized as much as possible to minimize confusion and expenses that would result from significantly different state and federal requirements.

The U.S. EPA regulation required that LSI engines nationwide meet the same 3.0 g/bhp-hr standard beginning in 2004 as required in California. The federal regulation also included a more stringent standard beginning in 2007, requiring that new LSI engines meet a 2.0 g/bhp-hr standard using a more rigorous transient testing protocol. It additionally contains evaporative emission and in-use requirements that were not contained in the 1998 California regulation. As with the California regulation, the federal rule contained a durability requirement.

2.3 2003 State Implementation Plan for Ozone

As a result of the State and federal regulations, new LSI engines are now 75 percent cleaner than an uncontrolled LSI engine, and will become even cleaner beginning in 2007. This is only one of numerous efforts that have allowed California's air quality program to achieve impressive clean air progress over the past decades. From 1980 to 2000, peak ozone concentrations in the Los Angeles area declined over fifty percent and the number of unhealthy days declined by almost half.

However, California still has a long way to go to achieve its clean air goals – over 90 percent of Californians still breathe unhealthy air at times each year. As a result, the ARB is now addressing the significant opportunity that exists to further reduce HC and NOx emissions from LSI equipment. There are several factors that contribute to this opportunity.

First, LSI equipment accounted for approximately six percent of all off-road emissions in 2000 and this percentage is increasing (ARB, 2003). Second, there are large numbers of uncontrolled LSI engines still in use. These engines can emit 12 g/bhp-hr or more of HC+NOx, contributing significantly to the smog problems in California. To put this in perspective, one uncontrolled LSI engine can emit as much pollution in three 8-hour shifts as one passenger car certified to California's cleanest standard during its entire life. Third, LSI engines are generally based on automotive engine technology and can thus incorporate advanced automotive-inspired emission control technologies to dramatically reduce emissions while still meeting operational requirements. Finally, zero-emission (electric now, and hydrogen fuel cell in the future) forklifts are available to provide even greater emission benefits while in many cases reducing overall life cycle costs.

In recognition of these opportunities, the 2003 SIP included two measures for LSI engines. The first measure proposed that California harmonize with the 2007 U.S. EPA 2.0 g/bhp-hr emission standard. The second measure proposed that emissions from existing or in-use LSI engines be reduced by 80% or to a 3.0 g/bhp-hr verification level. The latter measure also proposed that new standards be developed that reflected the availability of zero- and near-zero-emission technologies.

2.4 LSI Inventory

The ARB's OFFROAD emission inventory model, adopted in 1998 and updated continually, was used to estimate the emissions inventory for off-road LSI engines as well as for all other off-road mobile sources (ARB, 1998b). The emission inventory for off-road LSI engines includes total emissions of criteria pollutants and particulate matter. The OFFROAD model can be used to produce annual emission inventories as well as future year forecasts for the entire state or subtotals for each air basin and county in California.

2.4.1 Emission Inventory

The annual average statewide emissions inventory for certain off-road LSI equipment categories and the total off-road LSI category are provided in Table 2.0 below. As shown in the table, off-road LSI equipment contributed about 70 tons per day of HC and NOx in 2004. In 2010, the emissions inventory for these criteria pollutants is projected to be roughly 35 tons per day of HC and NOx. The emissions from off-road LSI are projected to decrease between 2004 and 2010 despite a projected five-percent increase in equipment population during this timeframe. This overall decrease in emissions from this equipment category can be attributed to the impact of the emission standards that were adopted in 1998 for 2001 and subsequent model year new off-road LSI engines. This trend, while certainly positive, does not match efforts to reduce emissions from other off-road categories.

Table 2.0: Off-Road LSI Equipment Emissions Inventory
2004, 2010, 2020 Statewide Annual Average[1]
(tons per day)

Year	Population	HC	NOx
2004	87687	15.4	54.8
2010	92104	7.5	28.3
2020	96964	4.4	19.0

[1] The current OFFROAD inventory shown in Table 2.0 does not reflect the impact of U.S. EPA's lower-emission standards for non-preempt off-road LSI engines starting in 2007.

The equipment categories shown in Table 2.1 represent the largest contribution to the overall off-road LSI inventory and are the focus of the regulatory proposal for fleet users. As calculated from Table 2.1, emissions from these three categories account for greater than 80 percent of the total HC+NOx off-road LSI emission inventory in 2004, and almost 94 percent of the non-preempt HC+NOx emissions. In terms of equipment population, the categories account for 60 percent of the total off-road LSI equipment population in 2004.

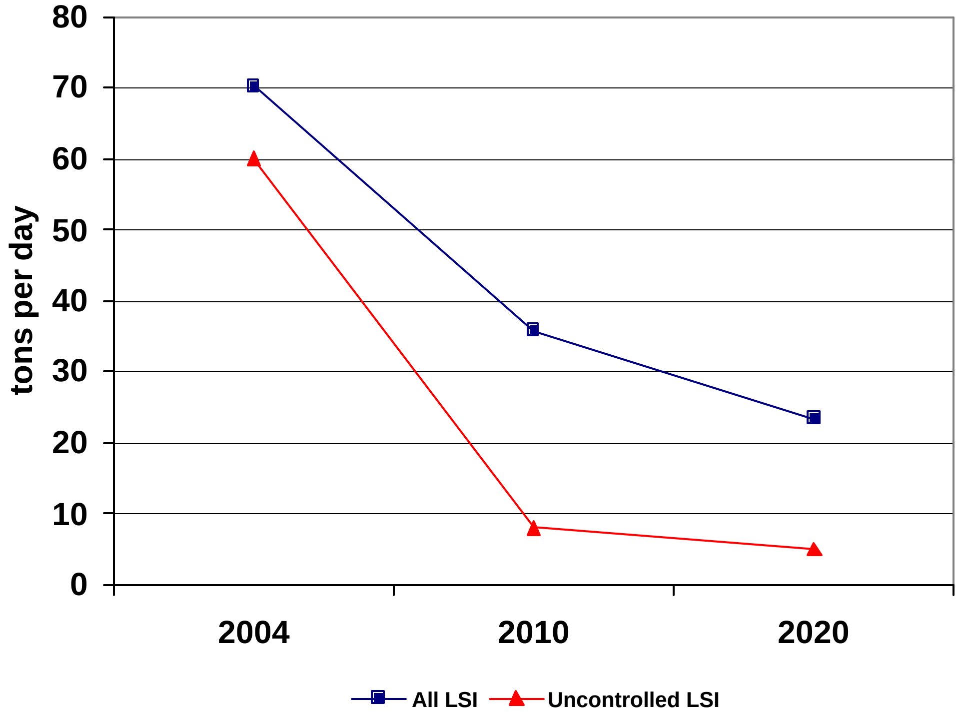
Table 2.1: Off-Road LSI Equipment Emissions Inventory for Certain Equipment Categories (tons per day)

Equipment Category	2004		2010		2020	
	HC	NOx	HC	NOx	HC	NOx
Industrial Forklifts	11.8	40.4	5.3	19.9	3.4	15.6
Airport Ground Support Equipment	0.6	3.3	0.3	1.5	0.2	1.0
Sweeper/Scrubbers	0.2	0.8	0.1	0.3	0.1	0.2

2.4.2 Uncontrolled Emissions Inventory

The emissions inventories presented in the previous section include both uncontrolled equipment and emission-certified equipment. Emission standards for off-road LSI engines were adopted by the ARB in 1998 and became effective through a phase-in schedule from 2001 through 2004. As such, uncontrolled equipment still accounts for a significant fraction of the total emission inventory from off-road LSI equipment. However, the emission contribution from uncontrolled equipment to the total LSI emission inventory will decrease as more new emission-certified equipment enters the fleets and older, uncontrolled equipment is retired. Figure 2.0 below shows the emissions inventory for uncontrolled equipment compared to the total LSI emissions inventory.

Figure 2.0: Emission Trends for Uncontrolled Off-Road LSI Equipment Compared to All Off-Road LSI Equipment Statewide Annual Average (HC + NOx, tons per day)

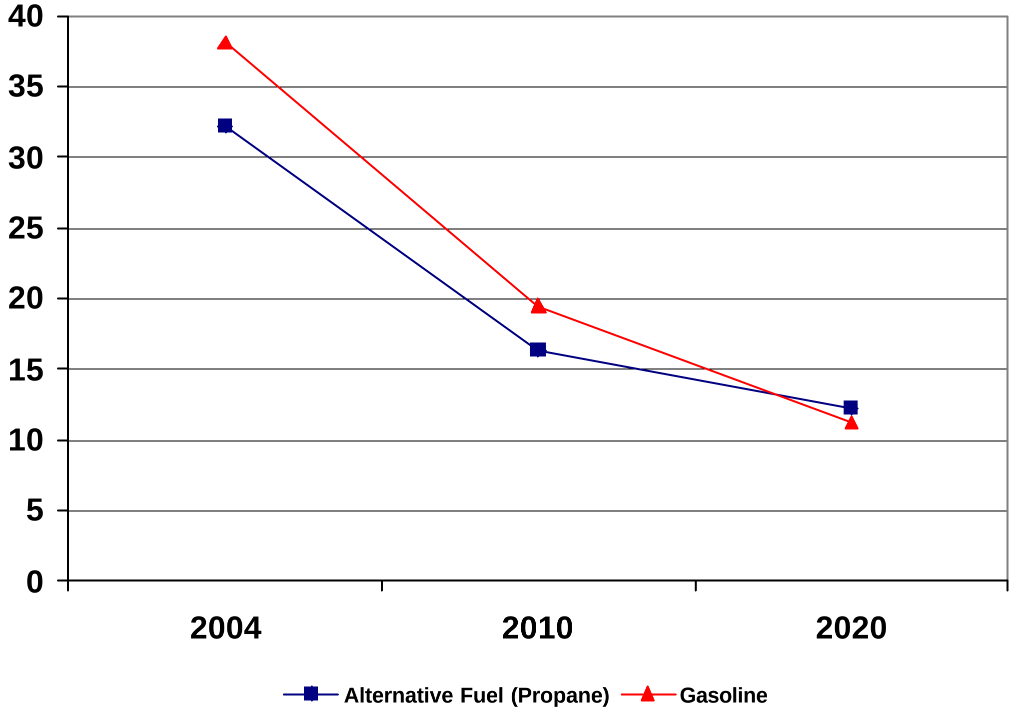


As discussed above, the 1998 regulations did not become fully effective until 2004. This effect can be seen in Figure 2.0 where the emissions from uncontrolled off-road LSI equipment represent the majority of the total emissions from all off-road LSI equipment. The relative emissions from uncontrolled off-road LSI engines are projected to decrease due to the expected retirement of older uncontrolled equipment and the increased penetration of emission-certified equipment. However, in the near term, the emissions from uncontrolled off-road equipment still remain significant at about 8 tons per day of HC+NOx statewide in 2010.

2.4.3 Gasoline and Alternative Fuels

The OFFROAD model distinguishes between gasoline LSI equipment and LSI equipment using alternative-fuels, mainly propane and some natural gas. Figure 2.1 shows the relative emissions contribution of gasoline and alternative-fuel off-road LSI equipment for 2004, 2010, and 2020. At the time of the 1998 OFFROAD emission inventory for LSI equipment, total propane emissions were slightly lower than total gasoline emissions because 38 percent (ARB, 1998c) of LSI forklifts and most other off-road LSI equipment such as generators and aerial lifts used gasoline. However, by 2020, emissions from propane-powered off-road LSI equipment are expected to be greater than those from gasoline-powered off-road LSI equipment. This is due to the increasingly greater use of propane equipment by fleets.

Figure 2.1: Emission Trends for Gasoline and Alternative-Fuel Off-Road LSI Equipment Statewide Annual Average (HC+NOx, tons per day)



2.4.4 <u>Typical Duty Cycle and Operational Characteristics</u>

Off-road LSI engines are used in a wide variety of applications and duty cycles. The ARB's OFFROAD emissions inventory model for off-road LSI equipment includes the following major equipment categories: agricultural, airport ground support, construction, light-duty commercial, light-duty industrial, and lawn and garden. Within each of these equipment categories are equipment types separated according to horsepower rating, fuel type, and federal preemption designations.

The diverse nature of off-road LSI engine applications is reflected in the wide array of duty cycles that can be observed for this group of engines and equipment. Off-road LSI equipment operation can range from constant speed operation to operations requiring very rapid transient response. The OFFROAD model contains default load factors for different equipment types, ranging from 0.20 to 0.95. Likewise, the annual hours of operation for LSI equipment range from 22 hours per year to 8,500 hours per year. (ARB, 1998c)

The OFFROAD model does not track the number of owned equipment versus leased or rented equipment. Since the majority of off-road LSI engines are used in commercial applications, fleet operators sometimes prefer to lease their equipment, especially when packaged with an equipment maintenance program. This arrangement would minimize their capital outlay as well as reducing the need to acquire in-house expertise to service the equipment. Fleet operators could also rent additional equipment to help them fulfill shorter-term or peak work demand. At the time the ARB first adopted emission standards for off-road LSI equipment in 1998, industry data showed that about 50 percent of all forklifts are either leased or rented (Gas Research Institute, 1995). Although the large percentage of leased and rented equipment does not have a direct impact on the emission inventory, it does create issues regarding responsibility to comply with regulatory requirements.

3 REGULATORY PROPOSAL

Staff has been working with LSI engine and equipment manufacturers and distributors, emission control system manufacturers, propane fuel refiners and distributors, end-user facility operators, federal regulatory agencies, environmental/pollution prevention and public health advocates and other interested parties since January 2004 to identify tools for reducing emissions from LSI engines and equipment. Staff evaluated many tools and analyzed numerous regulatory options. The most promising options initially analyzed were manufacturer lower-emissions standards, fleet average requirements and the required use of zero-emission equipment. Staff conducted workshops in May and August 2004 on these three primary options and has developed a combined proposal that includes elements of the first two. This combined approach was then presented at two workshops held in March 2005.

The central element of the proposed regulation is a near- to mid-term fleet average requirement for fleet operators. The requirement would mitigate emissions from uncontrolled equipment and encourage fleets to procure lower-emission or electric equipment. The fleet requirements would be coupled with lower-emission standards for engine manufacturers to ensure that cleaner LSI equipment would be available. To further reduce emissions and to provide options to fleet operators, the proposal includes optional tiered lower-emission standards for new engines and verification levels for retrofit emission control systems. Before discussing the fleet average requirements, the next section provides a summary of the proposed new engine standards for manufacturers.

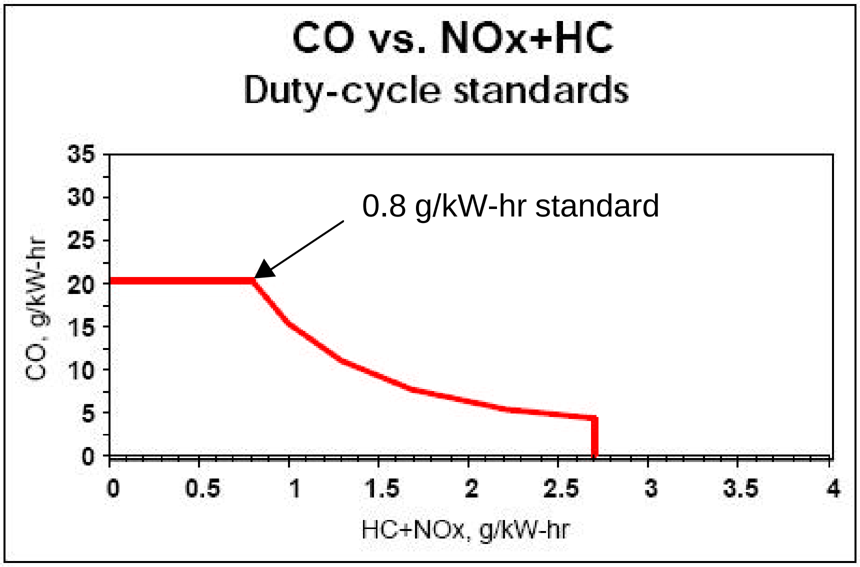
3.1 Manufacturer Lower-emission Standards Proposal

The proposed manufacturer lower-emission standards is comprised of three components as discussed below.

3.1.1 2007 Standard

The first component harmonizes the ARB standard for new LSI engines with the more stringent U.S. EPA emission standards and test procedures that become effective in 2007. Under this requirement, manufacturers of new 2007 and later model year engines would be required to meet nominal 2.0 g/bhp-hr (2.7 g/kW-hr) HC+NOx and 3.3 g/bhp-hr (4.4 g/kW-hr) carbon monoxide (CO) emission levels. The federal requirement also allows manufacturers to alternatively certify according to the following formula: $(HC+NOx) \times (CO)^{0.784} = 8.57$. This is shown in Figure 3.0. This alternative certification standard provides manufacturers the flexibility to let their CO emissions increase so that they may achieve lower HC+NOx levels.

Figure 3.0: Alternative Federal Certification



3.1.2 2010 Standard

The second manufacturer component would require that new 2010 and subsequent model year engines meet a 0.6 g/bhp-hr (0.8 g/kW-hr) HC+NOx standard with a corresponding CO emission standard of 15.4 g/bhp-hr (20 g/kW-hr). Staff does not believe that the 0.6 g/bhp-hr standard in 2010 is excessively stringent. In actuality, it mirrors the U.S. EPA's existing 2007 standard because it corresponds to the minimum HC+NOx level allowed by the U.S. EPA alternative certification formula above. Stated another way, the proposed 2010 standard is consistent with the 2007 standard, but limits calibration flexibility to the most stringent HC+NOx emission level to maximize ozone precursor benefits. The 0.6 g/bhp-hr (0.8 g/kW-hr) standard is represented graphically on the HC+NOx vs. CO emission trade-off curve in Figure 3.0 above by an arrow. Approximately three-quarters of the engine families that certified in 2004 for use in forklifts had combined tested HC+NOx emissions of 0.6 g/bhp-hr or below.

3.1.3 Optional Certification Standards

The third manufacturer component would establish **optional** lower-emission standards below the 2007 and 2010 mandatory standards. Under this component, model year 2007 through 2009 engines could be certified to optional tiered new engine standards of 0.1, 0.2, 0.4, 0.6, 1.0, and 1.5 g/bhp-hr HC+NOx (or the equivalent g/kW-hr standard). For model year 2010 and beyond, engines could be certified to optional standards of 0.1, 0.2, and 0.4 g/bhp-hr HC+NOx. These lower-emission standards provide fleet users additional flexibility in meeting the proposed fleet average emission level requirements discussed in the following section. The optional standards also provide those manufacturers that make their equipment less polluting an opportunity to certify at the lower standard and earn credit, thus providing additional incentives to develop cleaner LSI equipment.

3.1.4 Test Procedures

The regulatory proposal would incorporate by reference, with minor modifications, the test procedures adopted by the U.S. EPA as part of their regulations for LSI engines, finalized in 2002. In building on the efforts for ARB's 1998 regulation, EPA also added more stringent voluntary Blue Sky Series emission standards, new requirements for evaporative emissions, and engine diagnostics system. In most of the cases where individual provisions differ, the EPA language is more general than that adopted by ARB, rather than being incompatible. ARB staff has proposed that LSI regulations harmonize with EPA's language that will apply to 2007 model year and later LSI engines while maintaining ARB's current provisions, such as certification procedures and an in-use testing program. Appendix A.3 contains the regulatory amendments to U.S. EPA's test procedures.

3.2 Fleet Average Emission Level Proposal

ARB staff is proposing fleet average emission requirements (fleet averages) for large and mid-size fleets of forklifts, GSE, sweeper/scrubbers (with a displacement greater than one liter)[1], and non-GSE industrial tow tractors beginning January 1, 2009. Fleet size is determined by aggregating an operator's equipment in the State of California. Large LSI fleets as proposed are those with more than 25 pieces of equipment while mid-size LSI fleets would be those with 4 to 25 pieces of equipment.

Under the proposal, large fleets would have to meet a more stringent fleet average than mid-size fleets due to their greater flexibility in incorporating combinations of emission-reduction strategies. Likewise, the fleet average would be more stringent for the forklift portion of the fleet than for the non-forklift portion of the fleet.

[1] Forty-six percent of the engines that were certified in the 2004 model year for use in sweeper/scrubbers had a displacement of one liter or less (ARB, 2005). These engines are not subject to the LSI proposal and the equipment containing them is not subject to the fleet average requirement.

The fleet average would be determined using the certification levels of 2001 and newer LSI engines and the retrofit verification levels of engines with retrofit kits. To make the proposal less complex and less intrusive for the typical fleet operator while maintaining cost effective emission benefits, the fleet average will not incorporate load factor, horsepower, or hours of use.

The proposal provides the LSI fleet operator with the flexibility to use any combination of retrofits, lower-emission purchases, and zero-emission electric purchases to meet the fleet average emission level, which becomes progressively more stringent over time. The following table summarizes the proposed fleet average emission levels for forklift and non-forklift LSI fleets.

Table 3.0: Fleet Average Emission Level Requirements
(g/bhp-hr (g/kW-hr) of HC+NOx)

LSI Fleet Type	Number of units	By 1/1/2009	By 1/1/2011	By 1/1/2013
Large fleet – forklift component	26 +	2.4 (3.2)	1.7 (2.3)	1.1 (1.5)
Mid-size fleet – forklift component	4-25	2.6 (3.5)	2.0 (2.7)	1.4 (1.9)
Non-forklift fleet	N/A	3.0 (4.0)	2.3 (3.1)	1.7 (2.3)
Small fleet	1-3	No uncontrolled equipment by 1/1/2011[1]		

[1] Exempts low-use equipment: (250 hours per year or less) with hours-of-use meter

As a result of growth, fleet operators may find themselves having to comply with a more stringent fleet average. The fleet average proposal provides additional flexibility to the fleet operator by instituting two-year transition periods that correspond with the fleet average compliance dates. Thus, a large fleet would only be required to comply with the corresponding mid-size fleet average if they were a mid-size fleet on the compliance date. For example, on January 1, 2009, a mid-size fleet would have to meet a 3.5 g/kW-hr standard. If that same fleet, through growth, becomes a large fleet, they would not have to meet the 3.2 g/kW-hr requirement. However, they would have to meet the 2.3 g/kW-hr requirement for large fleets, beginning on January 1, 2011.

Conversely, through retirement, fleets may move to a lower fleet average category. In this case, the fleet would not be constrained to meet the fleet average requirement that corresponded to their size on the initial fleet average compliance date, but instead would be allowed to comply with the fleet average that corresponds to their current size. For example, on January 1, 2009, a large fleet must comply with a 3.2 g/kW-hr fleet average. However, if through retirement or another mechanism, the fleet subsequently becomes a mid-size fleet, then the mid-size requirement becomes effective immediately.

3.2.1 Hours of Use Exemption

Forklift and non-forklift equipment in medium and large fleets may be exempted from the fleet average emission level requirements if it meets the following provisions:

- The equipment is used, on average over any three year period, 250 hours per year or less,
- The equipment is equipped with an operational hours-of-use meter,
- The fleet operator maintains hours-of-use records for the piece of equipment, and
- The fleet operator addresses any uncontrolled emissions by January 1, 2011 by either retrofitting or repowering the equipment to a Level 2 verification level as described in Section 3.3.1 below or replacing the equipment with a new or used piece of equipment certified to a 3.0 g/bhp-hr HC+NOx emission standard or better.

3.2.2 Small Fleet Exemption

Small fleets with 1 to 3 pieces of equipment would be exempt from the fleet average requirement, but would be required to have no uncontrolled equipment by January 1, 2011. The proposal provides an hours-of-use exemption for equipment used by small fleets if the equipment meets the provisions noted in Section 3.2.1 above, except that the small fleet operator is provided until January 1, 2013, to address uncontrolled emissions from the small fleet.

3.2.3 Specialty Equipment Exemption

Specialty equipment is defined as equipment that has unique or specialized performance capabilities that perform prescribed tasks. Specialty equipment used in large and mid-size fleets is exempted from the fleet average requirements provided that:

- The Executive Officer approves the listing of the piece of equipment as specialty equipment,
- The cost of replacing or retrofitting the equipment is deemed by the Executive Officer to be excessive, and
- The equipment meets the first three provisions the hours of use exemption (see Section 3.2.1 above).

3.3 Proposed Verification Protocol for Retrofits

ARB staff is proposing a verification protocol for retrofit emission control systems to address in-use emissions and to provide fleet operators with additional options to meet the proposed fleet average emission level requirements. Such procedures will ensure that the retrofit systems deliver real and quantifiable emission reductions.

The proposed verification protocol (contained in Appendix B) would apply to manufacturers of retrofit systems sold in California. These systems include but are not limited to, closed-loop fuel control systems, fuel injections systems, and three-way catalysts.

3.3.1 Retrofit Emission Verification Levels

As shown in Table 3.1, the proposed verification protocol contains several LSI Retrofit Verification Levels that a manufacturer could choose to verify their systems. Depending on the level selected, a system could be verified on the basis of a percentage reduction or on the basis of an absolute emission level. This approach provides flexibility for manufacturers to determine the appropriate level of emission control that their technology achieves. The proposed LSI Retrofit Verification Levels would accommodate retrofit technologies that would reduce emissions from either uncontrolled engines or certified engines. Following is a brief discussion of the various LSI Retrofit Verification Levels allowed under the proposed verification test protocol.

LSI Level 1 is the minimum level that would be allowed for verification under the proposed protocol. This LSI Level applies to uncontrolled LSI engines and would require a minimum reduction of 25 percent of HC+NOx from the baseline uncontrolled emission level. LSI Level 2 requires that the system achieve either a 75 percent reduction of HC+NOx from baseline level, or an emission level of 3.0 g/bhp-hr of HC+NOx. Staff anticipates that the majority of retrofit technology would be able to achieve this level of emission reductions for LSI engines operating on LPG.

Table 3.1: Proposed LSI Engine Retrofit System Verification Levels

Classification	Percentage Reduction	Absolute Emission Level (g/bhp-hr HC+NOx)
LSI Level 1[1]	> 25%[2]	Not Applicable
LSI Level 2[1]	> 75%[3]	3.0
LSI Level 3a[1]	> 85%[4]	0.5, 1.0, 1.5, 2.0, 2.5
LSI Level 3b[5]	Not Applicable	0.5, 1.0, 1.5, 2.0

1 Applicable to uncontrolled engines only
2 The allowed verified emissions reduction is capped at 25 percent regardless of actual emission test values
3 The allowed verified percentage reduction for LSI Level 2 is capped at 75% or 3.0 g/bhp-hr regardless of actual emission test values
4 Verified in five percent increments, applicable to LSI Level 3a classifications only
5 Applicable to emission-controlled engines only

3.4 Alternative Compliance Option for Fleets used in Agricultural Crop Preparation Services

ARB staff is proposing an alternative compliance option for agricultural-related fleets that would allow additional time to control the highest emitting forklifts as long as steady verifiable progress is made. The proposal reflects the longer retention periods characteristic of agricultural-related operations, such as packing houses. Under this option, owners of agricultural-related fleets are required to control (to a 3.0 g/bhp-hr level or less) ten percent of their uncontrolled forklift fleet each year for ten years through retrofit, repower, replacement or retirement.

3.4.1 Hours of Use Exemption

Forklifts may be exempted from the agricultural fleet requirements if they meet the following provisions:

- The equipment is used 250 hours per year or less, on a three-year rolling average,
- The equipment is equipped with an operational hours-of-use meter, and
- The fleet operator maintains hours-of-use records for the piece of equipment.

3.4.2 Specialty Equipment Exemption

Forklifts having unique or specialized performance capabilities, as demonstrated to, and approved by, the Executive Officer of the ARB, are exempted from the agricultural fleet requirements provided that:

- The Executive Officer approves the listing of the piece of equipment as specialty equipment,
- The cost of replacing or retrofitting the equipment is deemed by the Executive Officer to be excessive, and
- The equipment meets the provisions of Section 3.4.1 above.

3.5 Fleet User Record Keeping Requirements

For enforcement purposes, the fleet average emission level proposal would require fleet operators to conduct a baseline inventory within six months of the operative date of the regulations under state law. Staff is requiring that baseline inventories be maintained beginning this early because of the three-year rolling averages that are built into the hours-of-use provisions of the regulation. The inventory would need to contain the following fleet average information: equipment type, make, model, serial number, and emission certification standard or retrofit verification standard at their facility. Users would be required to maintain records on file of their baseline inventory and subsequent inventories indicating acquisitions and retirements until June 30, 2016. The ARB will provide a simple electronic form for fleets to record their information.

3.6 Diesel Equipment

As mentioned in the regulatory authority discussion (Section 1.3), the ARB typically regulates diesel or compression ignition engines separately from LSI engines. The ARB is beginning a regulatory effort, separate from this proposal, to address emissions from off-road in-use diesel equipment. That effort will focus on reducing toxic particulate matter emissions from diesel equipment, including forklifts, through required retrofits in an expedited time frame.

4 FLEET AVERAGE COMPLIANCE SCENARIOS

This section describes the fleet average concept and compliance strategies, an alternative compliance option for agricultural fleets, the mandatory and optional tiered manufacturer lower-emission standards, and the retrofit verification protocol.

As discussed, staff is proposing fleet average emission requirements for large and mid-size fleets. The most common example of a large fleet is a distribution facility/warehouse or a large manufacturing facility. Operators that have multiple facilities statewide will likely fall into the large fleet category as well (for example, a home improvement warehouse may only have three or four forklifts per site, but could have dozens of sites statewide). A mid-size manufacturing facility or agricultural packing warehouse is a typical example of a mid-size fleet operator.

Large fleets would have to meet more stringent fleet average emission levels than mid-size fleets because they have greater flexibility and financial ability when incorporating combinations of emission-reduction strategies to achieve a prescribed level. The strategies include zero-emission technologies (such as electric forklifts), lower-emission standards (such as new equipment certified to optional lower-emission standards), and in-use reductions (such as retrofit systems).

The fleet average emission level would be more stringent for the forklift portion of the fleet than for the non-forklift LSI portion of the fleet. This reflects two observations. First, electric-powered forklifts are readily available for use in many applications and already comprise a major market share. The availability of electric equipment is not as prevalent in other applications where LSI engines are used. Second, because forklifts are the most prevalent application in the LSI category, it is more likely that there will be retrofit kits and new equipment certified to optional lower-emission standards available for fleets to incorporate into their fleet average. Non-forklift equipment covered under the fleet average includes sweepers and scrubbers, industrial tugs, and airport ground support equipment. Under the staff proposal, other LSI equipment would not be included in the fleet average.

The fleet average would be determined for all LSI equipment, both forklift and non-forklift using the certification levels of 2001 and newer LSI engines and the retrofit verification levels of engines with retrofit kits. Low usage equipment (250 hours per year or less) would be exempted from large and mid-size fleets for the purposes of the fleet average calculation. However, the emissions from this equipment would need to be addressed through retrofit, repower, replacement, or retirement by January 1, 2011.

Small fleets are defined as those fleets with one to three pieces of equipment. A small independent lumberyard is a good example of such a fleet. Small fleets would be exempt from the fleet average requirement, but would be required to have no uncontrolled equipment by January 1, 2011. Low usage equipment (250 hours per year or less) would not have to be addressed through retrofit, repower, replacement, or retirement until January 1, 2013.

4.1 Fleet Average Compliance Options

Equipment users can employ a variety of techniques to achieve prescribed fleet average emission levels. New procurement can be zero- or lower-emission LSI equipment. Existing or in-use equipment can be retrofitted with one or more of the same control technologies that have been incorporated into new lower-emission LSI equipment. Fleet owners may also repower older equipment with certified engines or purchase certified used equipment. Details of each of these options follow.

4.1.1 Zero-Emission Equipment

The simplest and most effective way to reduce a fleet's average emission level is through procurement of zero-emission equipment, especially forklifts. Electric forklifts are most typically used in indoor materials handling applications that do not require large lift capacities (i.e., warehouse/retail operations). Applications where electric forklifts are used extensively include confined spaces, cold storage and food retail (primarily grocery stores).

Although electric forklifts are primarily designed for indoor operations, a number of manufacturers are also including equipment features that enable electric models to be used in a wider variety of environments. These features include pneumatic tires (air filled) that allow the forklift to be used on unimproved surfaces, water proofing trucks or sealing the electronics compartment to make them water resistant for outdoor conditions, and alternating current motors that provide greater lift and travel speeds. Electric forklifts compete directly with LSI forklifts for many of the same work applications.

Electric forklifts have no exhaust emissions and extremely low upstream (power plant) emissions. Thus, electric forklifts can provide significant air quality benefits. The Electric Power Research Institute (EPRI) has prepared several reports (reference) on electric forklifts that identify other benefits in addition to improved air quality. Electric forklifts can have lower life-cycle costs when compared with LSI models. This is due to lower maintenance costs, lower fueling costs, and longer useful life. Although the initial capital cost of an electric forklift is higher than that of a comparable LSI forklift, the incremental cost can be recovered during the useful life. Because of the financial benefits to the end user, electric forklifts are already prevalent in some markets.

Electric forklifts include electric motor trucks with cushion or pneumatic tires (referred to as Class 1 forklifts); electric motor narrow aisle trucks (Class 2); and electric hand trucks or hand/rider trucks (Class 3) (ITA, 2005). Class 1 electric forklifts are available in a wide variety of lift capacities from 3,000 pounds to 20,000 or more pounds. According to market data evaluated by the ARB, most Class 1 forklifts sold today in the U.S. are in the 3,000-6,000 pound lift capacity range. Class 1 forklifts typically perform duties similar to LPG-powered Class 4 and 5 forklifts. The use of Class 2 forklifts has the added benefit of allowing warehouses to more easily convert to cost-saving narrow aisle operation. For the purposes of calculating the fleet average, fleet owners would be able to assign an emission level of zero (0.0) to Class 1 and Class 2 forklifts. Fleet operators would not be allowed to count Class 3 trucks toward their fleet average, because Class 3 trucks do not traditionally supplant Class 4 or 5 forklifts.

In general, an electric forklift can operate from one to two shifts before needing to be recharged. Some multi-shift operations employ battery swapping or fast charging to support the use of a 100 percent electric fleet. Fast charging can have the additional benefit of eliminating dedicated battery charging rooms. However, staff recognizes that facility or duty cycle constraints may preclude some users from moving toward a 100 percent battery electric fleet. These fleets may want to consider another zero-emission power option - fuel cell forklifts. Numerous fuel cell, battery and traditional industrial truck manufacturers are partnering to develop programs that demonstrate how hydrogen fuel cells can be successfully integrated into industrial truck operations. Several of these partnerships are expecting to commercialize their technology in the next two to three years. Depending on lift truck power requirements and applications, a proton exchange membrane fuel cell stack is matched with an appropriate battery pack resulting in a clean, quiet and reliable operation. Benefits of fuel cell charging include time-savings from the elimination of battery changes, no loss in lift capacity or drop in power as the shift progresses, and longer battery life. Also, with fuel cell forklifts, dedicated battery-charging rooms can be eliminated, freeing up valuable floor space.

4.1.2 New Equipment Certified to Optional Lower-emission Standards

If neither of the zero-emission options discussed above meet the needs of a particular operator, they may want to consider reducing their fleet average and resulting emissions through procurement of new lower-emission equipment that is cleaner than both the current 3.0 g/bhp-hr HC+NOx standard and the 2007 2.0 g/bhp-hr standard. Based on current certification data as well as discussions with manufacturers, ARB staff believes that LSI manufacturers will be able to offer forklifts at emission levels significantly below these current standards. A discussion of the technologies expected to achieve even lower levels is contained in Section 5, Technology Review.

Under the proposal, model year 2007 and subsequent engines could be certified to optional tiered new engine standards of 0.1, 0.2, 0.4, 0.6, 1.0, and 1.5 g/bhp-hr. A

January 20, 2005, Manufacturers Advisory Correspondence already provides that manufacturers can voluntarily certify their 2005 and 2006 model year engines to these interim lower-emission standards up to 2.0 g/bhp-hr, and one major manufacturer has already submitted two engine applications to the ARB for early certification to the 2.0 g/bhp-hr level. These engines will provide equipment users with greater flexibility in meeting the proposed fleet average emission levels in Table 3.0.

4.1.3 In-Use Controls

One of the most expedient ways to reduce LSI fleet emissions is to retrofit in-use engines. This entails modifying or upgrading components on the engine and/or fuel system with ARB verified retrofit emission control systems. An example of a retrofit emission control system is a closed-loop fuel control system coupled with a three-way catalytic converter, which could be added at the time of scheduled engine maintenance. Such systems have demonstrated an ability to reduce emissions by 75 percent or more.

ARB staff is proposing a procedure for the optional verification of retrofit systems for in-use LSI engines. The proposed LSI retrofit verification procedure, contained in Appendix B, will ensure that the systems sold for use on existing engines and equipment are functional, durable, and meet claimed emissions reductions. The proposed procedure establishes the procedures that manufacturers must follow to demonstrate that their system provides real and durable HC+NOx reductions while at the same time, limiting CO emissions to existing acceptable levels. While developing the procedure, staff addressed important issues with industry groups, including verification of reduction claims, durability, warranty, and in-use emissions. The proposed procedure is consistent with existing diesel verification procedures but adapted to consider the unique issues related to LSI engines.

High-efficiency retrofit systems may not be available for all engines or equipment as anticipated in the 2002 SIP commitment. In recognition of this, and in order to facilitate the implementation of current emission control strategies, ARB staff is proposing multiple verification levels. These tiered levels provide a hierarchy for emission reduction technologies. The proposed levels should broaden both the spectrum of control technologies available and the number of applications that can be controlled.

As an alternative to retrofits, LSI equipment users may repower or replace existing engines or equipment with new engines or used equipment that are certified to lower-mission standards. By using this strategy the users would have the option to either replace their in-use uncontrolled engine with an engine that is certified to a 3.0 g/bhp-hr HC+NOx or lower-emissions standard, or purchase a used piece of certified equipment. Both of these are cost-effective strategies for lowering emissions from in-use equipment.

4.2 Fleet Average Compliance Scenarios

One of the main advantages of the proposed fleet average requirement is that it allows individual fleet users the flexibility to tailor their compliance strategy to the specific needs of their fleet. Some fleets may decide to purchase additional electric forklifts, others may prefer to modernize their fleet, and still others may pursue lower-emission equipment. Some fleets, primarily those with a substantial percentage of electric equipment, may not need to take any additional steps. This flexibility makes it impossible to precisely determine how fleets will comply. However, the staff has developed a few scenarios for illustrative purposes.

One factor that will significantly impact a fleet average value is the number of uncontrolled LSI engines. Uncontrolled forklifts have emissions of approximately 12 g/bhp-hr HC+NOx, while current LSI equipment meet a level of 3.0 g/bhp-hr (uncontrolled engines were available through 2003, and some uncontrolled equipment was available in 2004, even though it started being phased out in 2001). The scenarios discussed below assume that by 2009, fleets have no uncontrolled equipment, i.e., all uncontrolled equipment has been retrofitted, repowered, replaced, or retired. The scenarios also assume an average fleet turnover of seven years. According to ARB's inventory, over 88 percent of the forklifts within California are seven years old or newer. Fleets with a shorter fleet turnover rate (more modern fleets) would make it easier to comply with the requirements, while a longer turnover rate (older fleet) would require the fleet to take additional measures to comply.

By January 1, 2009, without being subject to fleet standards, a typical baseline fleet with a uniform seven-year turnover rate that has converted its uncontrolled equipment and has no electric equipment would have a fleet average of 2.7 g/bhp-hr HC+NOx. As proposed in Table 3.0, a large fleet would be required to meet a standard of 2.4 g/bhp-hr and a mid-sized fleet would be required to meet a standard of 2.6 g/bhp-hr.

4.2.1 Large Fleets

Under the staff proposal, large fleets would need to meet a fleet-average emission requirement of 2.4 g/bhp-hr by January 2009. The simplest and most effective way to meet the requirement would be to establish a modest electric equipment component. A fleet could achieve the 2.4 g/bhp-hr requirement by ensuring that approximately 11 percent of the equipment procured annually since 2002 is electric.

Fleets would not have to rely on electric equipment to meet the fleet average requirement - they can also comply by procuring lower-emission equipment. Newer fleets (those that more routinely replace older equipment) would have the easiest time complying with the requirements. Older fleets with longer turnover rates would have to be more aggressive in their procurement of lower-emission equipment to comply with the requirements. A fleet with a seven-year procurement cycle (and no electric equipment) could meet the proposed fleet average standard by procuring 2.0 g/bhp-hr equipment one year early in 2006 in conjunction with cleaner 1.0 g/bhp-hr equipment in 2008.

To meet the proposed 2011 fleet average requirement of 1.7 g/bhp-hr, a fleet would have to reduce their fleet average by 23 percent over the 2011 baseline. Again, the easiest way for a fleet to achieve the requirement is to incorporate electric equipment. A fleet with uniform turnover and a 23 percent electric component beginning in 2004 would meet the requirement. A fleet choosing not to incorporate any electric equipment would need to be more aggressive in their purchasing of lower-emission equipment. In addition to what they had done to meet the 2009 fleet average requirement, a fleet with a typical seven-year turnover rate would have to procure 1.0 g/bhp-hr equipment in 2009.

Finally, to meet the proposed 2013 fleet average requirement of 1.1 g/bhp-hr, a fleet would have to reduce their fleet average emission level by 27 percent over the 2013 baseline. As such, a fleet that incorporated a 27 percent electric component into their normal procurement cycle beginning in 2006 could meet the requirement. A fleet choosing not to incorporate any electric equipment would need to continue being more aggressive in their procurement of lower-emission equipment. In addition to what they had done to meet the 2009 and 2011 fleet average requirements, the fleet with a seven-year procurement cycle would have to additionally procure 0.4 g/bhp-hr equipment in 2012.

4.2.2 Mid-Size Fleets

Under the proposal, mid-size fleets would need to meet a fleet average emission level requirement of 2.6 g/bhp-hr. As with large fleets, mid-size fleets may meet the requirement through procurement of electric or lower-emission equipment. Since mid-size fleets may have less flexibility than large fleets have, their requirements are less stringent. Thus, they can comply with a smaller electric component or longer procurement cycle.

A typical mid-size fleet may achieve the 2.6 g/bhp-hr requirement with a uniform seven-year turnover rate by procuring 4 percent electric equipment each year beginning in 2002. The same fleet may also meet the standard without incorporating any electric equipment as long as they are on a typical seven-year procurement cycle and procure 2.0 g/bhp-hr equipment in 2006 (one year early). A fleet choosing to be on a longer eight-year procurement cycle would have to be more aggressive, procuring 2.0 g/bhp-hr equipment in 2006 and 1.5 g/bhp-hr equipment in 2008.

To meet the proposed 2011 fleet average requirement of 2.0 g/bhp-hr, a fleet would have to reduce their fleet average by 9 percent over the 2011 baseline. A fleet with uniform turnover and a 9 percent electric component purchase beginning in 2004 would meet the requirement. A fleet choosing not to incorporate any electric equipment might need to be more aggressive in their purchasing of lower-emission equipment. In addition to what they had done to meet the 2009 fleet average requirement, the fleet with a seven-year turnover rate would need to continue to procure complying equipment. The fleet with an eight-year turnover rate would have to procure 1.0 g/bhp-hr equipment in 2009 (in addition to what they had done to meet the 2009 fleet average requirement).

Finally, to meet the proposed 2013 fleet average requirement of 1.4 g/bhp-hr, a fleet would have to reduce their fleet average emission level by 7 percent over the 2013 baseline. As such, a fleet that incorporated a 7 percent electric component purchase into their normal procurement cycle beginning in 2006 could meet the requirement. A fleet on a six-, seven-, or eight-year procurement cycle could still comply with the requirement without incorporating any electric equipment and without procuring lower-emission equipment after 2009 as long as they had procured appropriate lower-emission equipment to meet the 2009 and 2011 requirements.

4.2.3 Non-Forklift Fleets

The fleet standards for non-forklifts are set to be conservative while still requiring the fleet to retrofit, repower, or retire uncontrolled equipment. This allows compliance with the fleet average through a steady turnover of the fleet with an eight-year life. It also allows for some non-availability of retrofit systems in the early years. Any availability of equipment meeting optional lower-emission standards in this category will make compliance with the proposed standards easier.

4.3 Alternative Compliance Option for LSI Equipment for Fleets used in Agricultural Crop Preparation Services (Agricultural Fleets)

The proposed fleet average emission levels for forklifts discussed above are predicated upon a seven-year fleet turnover. That turnover rate reflects the fact that 88 percent of the LSI equipment inventory is seven-years old or newer and 95 percent is nine years old or newer. It is acknowledged that some fleets will have older equipment than others – making the fleet average slightly more difficult for those with the oldest, dirtiest fleets. However, these are also the exact fleets that need to cleaned up the most. In addition, nearly all fleets should be able to reasonably incorporate retrofits into their fleet average, since retrofits are expected to be available for most forklifts newer than 1996. The retrofits are moderately-priced and even pay for themselves within four years through better fuel usage.

However, as the equipment gets older, several factors conspire to decrease the feasibility of retrofits. These include the general state of the equipment, availability of retrofit kits (kit manufacturers need economy of scale to offer reasonably priced kits), and value of the equipment relative to the cost of performing a retrofit. The average age of the forklifts owned in agricultural-related fleets, such as packinghouses, is 19 years. Retrofits will be available for some, but not the majority of these forklifts. Consequently, agricultural operations that own the equipment will not have a lower-cost retrofit option generally available and would have to either repower or replace their equipment. Consequently, even though these forklifts are the ones specifically targeted by these regulations, staff believes it is appropriate to give the agriculture-related industries a relaxed standard and additional time as long as steady and verifiable progress can be demonstrated.

To address this issue, staff is proposing that owners of fleets that perform agricultural crop preparation services for market (packinghouses, cotton gins, nut hullers and processors, dehydrators, feed and grain mills, etc.) be allowed to concentrate their efforts on removing uncontrolled equipment from their baseline 2006 fleet over a longer term. Diesel forklifts and "in-field" forklifts are exempt from this proposal.

Under this proposal, agricultural-related fleets comprised of owned equipment would have until 2016 to completely address their uncontrolled equipment through retrofitting, where feasible, repowering or retirement. Fleets are required to make incremental progress on this goal; each year, 10 percent of a fleet's baseline of uncontrolled forklifts must be controlled to a 3.0 g/bhp-hr or lower HC+NOx level. A fleet may retain uncontrolled lifts in exceedance of their incremental progress provided that they are in compliance with an overall 3.0 g/bhp-hr fleet average through procurement of electric or lower-emission forklifts.

As discussed in Section 3.4.1, agricultural-related fleets would also be able to use the low-usage and specialty equipment exemptions. Specifically, forklifts that are used 250 hours per year or less, on a three-year rolling average, are not included in the incremental progress determinations provided that: (1) they have an hours-of-use meter, (2) their hours of use are logged and remain at or below 250 hours per year, and (3) the forklift is either controlled to a 3.0 g/bhp-hr HC+NOx level or replaced/retired by the final compliance date. In addition, specialty equipment is excluded from the incremental progress determinations provided that: (1) it is used 250 hours per year or less, on a three year rolling average, (2) it has an hours-of-use meter, and (3) the hours of use are logged. Staff has not established a date by which specialty equipment must be controlled to a 3.0 g/bhp-hr HC+NOx level or replaced/retired, but instead has committed to revisit the issue at a later date.

4.4 Manufacturer Lower-emission Standard Compliance

The proposed manufacturer lower-emission standard has three components. The first component harmonizes with more stringent U.S. EPA Tier 2 emission standards and test procedures that become effective in 2007. Under Tier 2, manufacturers of 2007 and later model year engines must meet a nominal 2.7 g/kW-hr (2.0 g/bhp-hr) HC+NOx emission standard and a 4.4 g/kW-hr (3.3 g/bhp-hr) carbon monoxide (CO) emission standard. Although these standards are nominally referred to as the 2007 “2.0 g/bhp-hr standard,” the requirement actually allows manufacturers the flexibility to certify at any HC plus NOx (HC+NOx) level between 2.7 and 0.8 g/kW-hr. To do so, manufacturers may certify according to the following formula:

$$(HC+NOx) \times (CO)^{0.784} = 8.57$$

Thus, the certification standard provides manufacturers with the flexibility to increase CO emissions as they achieve lower HC+NOx levels. (This curve is shown graphically in Figure 3.0). The ARB is proposing to incorporate these provisions into the first component of our manufacturer lower-emission standards.

In general, U.S. EPA's analysis shows that any point along this curve is equally stringent (i.e, a high HC+NOx level with a low CO standard is equivalent to a low HC+NOx standard with a higher CO level). Once manufacturers incorporate the necessary technology to achieve a point on this curve, they can then move along this curve with calibration changes. As an alternative, manufacturers have the ability to lower all three pollutants with technology improvements, as discussed in Section 5, Technology Review.

ARB and U.S. EPA regulatory and certification staff are working together to ensure consistency between the two regulations to the extent possible, and to identify where the two regulations diverge. In general, the ARB's certification and testing requirements will not change, with the exception that manufacturers will have to certify 2007 and subsequent model year engines using the transient test cycle. Manufacturers have requested that the ARB allow the deterioration factors (DFs) to be determined using the previous steady-state test cycle. Consequently, ARB staff is proposing that this option be available for model year 2007-2009 engines.

The second component of the manufacturer requirement would lower the ARB emission standard for 2010 and subsequent model year engines to 0.6 g/bhp-hr HC+NOx with a corresponding CO emission standard of 15.4 g/bhp-hr, consistent with the U.S. EPA formula. This standard corresponds to the minimum HC+NOx level on the HC+NOx versus CO emission trade off curve established by the U.S. EPA optional certification formula. As such, the proposed 2010 standard is essentially equivalent to the 2007 U.S. EPA requirement, but without the flexibility to increase HC+NOx emissions. Because the ARB's proposal remains consistent with the U.S. EPA standards, manufacturers will still have the ability to certify one engine family to nationwide standards.

In California, reducing ozone is a high priority, therefore the ARB proposal is able to ensure the maximum emission benefits by choosing the lowest HC+NOx point on the U.S. EPA curve. Based on an analysis by the U.S. EPA, staff believes that by staying along the curve, manufacturers will be able to meet the proposed 2010 emission standards for most engines with calibration changes. This allows California to achieve reductions of smog-forming emissions in the quickest, most cost effective way. For some engines, calibration changes alone may not be enough and technology improvements (e.g. increased catalyst size and volume) may be necessary.

Staff proposes to extend the 0.6 g/bhp-hr emission standard compliance deadline for small volume manufacturers to the 2013 model year. By ARB definition, small volume manufacturers produce a total of less than 2,000 large spark-ignition engines annually for sale in the United States.

The third component of the manufacturer requirement establishes optional lower-emission standards and was discussed as a strategy for complying with the fleet average emission level requirements in Table 3.0. Under this component, model year 2007 and subsequent engines could be certified to optional tiered new engine standards of 0.1, 0.2, 0.4, 0.6, 1.0, and 1.5 g/bhp-hr HC+NOx. The January 20, 2005, Manufacturers Advisory Correspondence already provides that manufacturers may voluntarily certify their 2005 and 2006 model year engines to these standards plus 2.0 g/bhp-hr HC+NOx, and one of the major manufacturers has already submitted two engine applications to the ARB for 2.0 g/bhp-hr certification. These lower-emission standards provide fleet users additional flexibility in meeting the proposed fleet average emission level requirements discussed previously. These standards also provide those manufacturers that make their equipment less polluting an opportunity to certify at the lower standard, thus providing additional value to the fleet owner.

As outlined in earlier sections, staff is pursuing a fleet average approach as the most cost effective and flexible method of achieving reductions in the near and mid-term. However, as staff was developing the overall proposal, it became clear that relying entirely on the fleet average in the long-term would not be appropriate. As the fleet average emission levels become lower, the absolute difference between them, in grams, becomes very small and the fleet average provides less of its original flexibility. In addition, the fleet average approach is more resource intensive on the fleets, in terms of record keeping, and on the regulatory agencies, in terms of outreach and enforcement.

By focusing on the fleet average approach in the early years, the ARB is providing LSI engine and equipment manufacturers significant flexibility to establish their long-term planning. Several manufacturers have commented that their current focus is on complying with the upcoming 2007 emission standards of 2.0 g/bhp-hr, and the associated changes in test procedures. This proposal allows them to continue that focus and gives them sufficient time following the 2007 standard to design to the next level – the proposed 0.6 g/bhp-hr standard. However, other manufacturers have commented that they do not want to be continually redesigning their systems every three or four years and would like to design once for the long-term. This proposal allows them to design toward that emission level and to benefit by bringing that product to market under the optional lower-emission standards.

5 TECHNOLOGY REVIEW

Off-road LSI engines are similar to automotive engines, but have traditionally lacked some of the automotive-style emission controls that have been in use for more than 25 years. While off-road LSI engines are exposed to duty cycles that can be more strenuous than those of their automotive cousins, they are suitable candidates for control, and manufacturers are now applying automotive-style emission control technologies to LSI engines to reduce emissions. These technologies include closed-loop fuel controls, fuel injection, and three-way catalytic converters.

5.1 Emission Control Strategies

Since 1980 automotive emission control systems have used a closed-loop fuel control system to help reduce emissions. These systems use sensors to monitor exhaust gas concentrations, and feed this information back to an electronic control module, which in turn keeps the air to fuel mixture at an optimum level. To help ensure more precise metering of fuel and optimum combustion, carburetors have been replaced by sequential fuel injection. Today's advanced systems maintain an extremely tight stoichmetric air to fuel balance during nearly all engine operations. This is important because wide fluctuations from the stoichiometric position will result in reduced efficiency in controlling HC, NOx, and CO as well as reduced durability of the control system.

Central to automotive emission control systems is the three-way catalytic converter. Automotive manufacturers have installed tens of millions of them each year for more than 25 years. They are an integral component of automotive emission control systems that have allowed the automotive fleet to meet progressively lower-emission standards – effectively reducing concentrations of HC+NOx and CO by more than 95 percent.

5.2 Emission Controls for LSI Engines

The advanced three-way catalysts are components of new LSI retrofit kits and new engines and have been demonstrated to be robust. Staff expects that LSI manufacturers will use a closed-loop fuel control system in conjunction with a three-way catalytic converter to achieve the 2007 standard of 2.0 g/bhp-hr (MECA, 2003). But there is still plenty of room for further reductions. After all, an engine that is certified to the 2.0 g/bhp-hr standard would still emit ten or more times the emissions of a new 2005 light-duty vehicle. This reflects the slower adoption of newer emission control technologies into LSI equipment.

Current light-duty vehicles have emissions that are less than one-tenth of forklift emissions while in use for several reasons. Today’s light-duty vehicles have larger catalytic converters, with more precious metal loading, higher cell densities and more effective washcoats than LSI engines. These differences can lead to greater efficiency of the catalytic converter as well as improved durability.

Light-duty vehicles use catalysts that are larger, as a percent of engine displacement, typically 70 to 80 percent. In contrast, LSI catalyst volumes are much lower, between 40 to 60 percent of engine displacement. Precious metal loading of the catalytic converter in a current LSI application is typically half of that in automotive applications. Finally, LSI catalysts typically have an "older automotive grade" single layer washcoat using less sophisticated materials in contrast to today's multi-layered washcoats that increase precious metals performance (MECA, 2004).

Adaptation of the improved automotive technologies noted above to LSI application can provide significant emission reductions. Already, even with less-sophisticated emission control systems, more than fifty percent of the LSI engines certified by the ARB for the 2004 model year had test emission levels of less than 1.0 g/bhp-hr (less than one-third of the current standard), some less than 0.5 g/bhp-hr, with the lowest coming in at 0.1 g/bhp-hr due to the use of improved systems (ARB, 2005a).

5.3 Impact of Transient Testing

Some manufacturers have expressed concerns about the impact of the 2007 transient test cycle on these numbers. To date, information provided by the Southwest Research Institute indicates that, under the transient test cycle, hydrocarbon emissions from an LPG engine increased by about 30 percent, but NOx emissions remained relatively constant. In a review of 13 forklift engine families (of 19 total) in our 2004 certification test database, NOx constituted approximately 50 percent of the HC+NOx emissions.[2] At 50 percent HC, the new test cycle could lead to a potential emissions increase of 15 percent over those under the steady state test cycle. However, all but one of the 13 engine families would still have an HC+NOx certification level of less than 1.0 g/bhp-hr because in instances where the HC emissions were high, the corresponding NOx emissions were low.

To date, transient cycle test data has been limited and staff has not seen any test data to demonstrate that manufacturers will have difficulty achieving the proposed standards under transient testing. Meanwhile, test results from emission control device manufacturers using new catalysts and other emission control technologies, while not performed under the transient test cycle, show that emissions can be reduced by more than 90 percent when compared to the pending 2007 standard (SwRI, 2004).

5.4 Lead Time

As discussed in Section 4.4, for most engines, the proposed 2010 standard may be accomplished with calibration changes alone. However, for those manufacturers that need further reductions, the technology to reach these levels is clearly available from the automotive sector and is cost-effective. The proposed effective date of 2010 was established to provide manufacturers sufficient time, in the event it is necessary to design and adapt this technology into the LSI applications.

When the U.S. EPA promulgated their LSI standards they stated that they believed the three-year period between the 2004 Tier 1 and 2007 Tier 2 emission standards (3.0 and 2.0 g/bhp-hr, respectively) allowed manufacturers sufficient lead time to meet the more stringent standard. They went on to state that they expected the emission control technologies for the 2004 emission standard to be able to meet the 2007 standard with additional optimization and testing. Analogously, ARB staff expects that three years will be sufficient time for manufacturers to further optimize the emission control technologies

[2] Historically, NOx emissions constituted 80% of the total LSI emissions (September 1998 LSI Staff Report)

projected to meet the 2007 U.S. EPA 2.0 g/bhp-hr requirement so that it will also be able to meet the 2010 ARB 0.6 g/bhp-hr requirement.

6 ENVIRONMENTAL IMPACTS

6.1 Air Quality Impacts

The emissions benefits for the fleet average emission requirements incorporated input factors from the OFFROAD model (Table 6.0). Staff calculated the baseline fleet average emission level based on a typical fleet that purchases emission-compliant equipment according to a pre-determined rate of equipment turnover, assumed to be seven years for forklifts and nine years for all LSI equipment. The baseline fleet average emission level is the mean of the high and low baseline levels. The high baseline assumes that a fleet procures new equipment that is certified to the highest emission standard legally allowed, while the low baseline assumes that a fleet procures new equipment that is certified to the lowest emission standard available, even if that standard is cleaner than required by the regulation. The baseline fleet average emission level is then compared to the staff's proposed fleet average emission levels and extended to all affected fleets to estimate the amount of emission benefits.

For the requirement on small fleets to have no uncontrolled equipment, staff assumes that LSI retrofit systems would achieve a 75 percent reduction from baseline uncontrolled emission rates. This assumed level of control efficiency is then applied to the estimated number of pieces of LSI equipment in small fleets that would be addressed by the regulation to obtain the estimated emission benefits. Finally, the emission benefits that were estimated for implementing the proposed new lower-emission standards were determined based on the difference in emission levels between the current and the proposed new emission standards, new equipment sales volume, and average activity factors for LSI equipment.

Table 6.0: OFFROAD Model Input Factors

Input	Unit	LSI Forklifts	Non-Forklift LSI Equipment	All LSI Equipment[1]
Horsepower	hp	64	62	63
load factor	unitless	0.30	0.59	0.45
activity	hours/year	1,800	740	1,236
2010 population	unitless	43,265	49,242	92,507
2020 population	unitless	46,462	50,501	96,963
life	years	7.0	11.0	9.1

1 Population-weighted

Table 6.1 lists the 2010 and 2020 estimated emission benefits of the proposed regulation based on an analysis of available information, including industry market data, industry's input, and emission inventory data from the ARB's OFFROAD model.

Table 6.1: Estimated Statewide Emission Benefits

Staff Proposal Element	HC+NOx Emission Reductions (tons per day)	
	Year 2010	Year 2020
Fleet Average Emission Requirements [1]	11.1	0.0
Small Fleet Requirements [2]	0.6	0.0
0.6 g/bhp-hr Engine Standard and Optional Lower-emission Standards Requirements	1.9	6.6
Total	13.6	6.6

1 These requirements apply to fleets with 4 or more pieces of off-road LSI equipment.
2 These requirements apply to fleets with fewer than 4 pieces of off-road LSI equipment.

Table 6.2 shows the estimated 2010 and 2020 emission benefit in of the staff's proposal for the South Coast Air Basin, relative to the SIP emission reduction commitment for that region.

Table 6.2: Estimated South Coast Air Basin Emission Benefits

	HC+NOx Emission Reductions (tons per day)	
	Year 2010	Year 2020
2003 SIP Commitment	4.4[1]	3.3[1]
Staff's Proposal	6.3[2]	3.0[2]

1 The 2003 SIP provided an emission reduction range of 2.8 to 6.0 tons per day in 2010 and 1.5 to 5.1 tons per day in 2020. The mean is 4.4 tons per day in 2010 and 3.3 tons per day in 2020.
2 Assumes South Coast Air Basin LSI equipment population is 46 percent of the statewide LSI equipment population.

6.1.1 2010 Emission Benefit Calculations

The emission benefit numbers in Table 6.1 are averages of the high and low estimates for each of the three elements of the staff proposal. The fleet average high estimate is the difference between the emissions, in tons per day associated with a high baseline fleet average and the emissions from the fleet requirement, while the low is the difference between the low baseline fleet average and the fleet requirement. Both the high and low baseline fleet average emissions for medium and large forklift fleets and non-forklift fleets (greater than 3 units), are calculated based on the inputs in Table 6.0 and an estimated 2010 forklift fleet average high of 5.3 g/bhp-hr and low of 3.4 g/bhp-hr and a 2010 non-forklift fleet average high of 6.8 g/bhp-hr and low of 5.5 g/bhp-hr. The fleet requirement emissions are based on the inputs in Table 6.0 and a fleet average of 2.4 for large fleets, 2.6 for medium fleets, and 3.0 for non-forklift fleets.

The small fleet high estimate assumes 20 percent of the population (equivalent to the percent of the population in fleets with 1-3 units), and a 75% control efficiency of the emissions from the uncontrolled LSI fleet (approximately 19% of the total HC+NOx emissions proportionate to the uncontrolled portion of the LSI fleet). We assume that all of the retrofits occur in 2010 in advance of the January 1, 2011 requirement, and that they are evenly distributed throughout the year. As a result, the assumed 2010 benefit is actually one-half of the estimated benefit. The 2011 benefit is actually twice the 2010 benefit. The benefit from retrofits in subsequent years declines to zero by 2020 as the longer-term requirements are fully implement. The small fleet low estimate assumes that 95 percent of LPG-powered LSI equipment and 75 percent of gasoline-powered LSI equipment would be retrofitted.

The benefit associated with the new engine and optional lower-emission standards assumes the “All LSI Equipment” inputs from Table 6.0. The high benefit assumes the difference between the 2.0 g/bhp-hr standard and a 0.6 g/bhp-hr standard. The low estimate assumes the same input factors but a difference between a 1.0 g/bhp-hr standard and the 0.6 g/bhp-hr standard, reflecting the fact that some fleets would have purchased lower-emission engines to comply with the fleet average. As with the small fleet benefit, the 2011 benefit is actually twice the 2010 benefit and continues to grow in subsequent years as the longer-term requirements are fully implement.

6.1.2 2020 Emission Benefit Calculations

By 2020, the 0.6 g/bhp-hr standard will have been in effect for 10 years, longer than the average turnover rate for fleets. As such, a fleet procuring new equipment each year will have a fleet average of 0.6 g/bhp-hr – well below the most stringent fleet average requirement in 2013. Therefore, there are no emission benefits attributable to the fleet average component of the proposal in 2020. Similarly, small fleets are required to address emissions from uncontrolled equipment by January 1, 2013. No additional requirements exist for small fleets between 2013 and 2020, so there are no emission benefits attributable to the small fleet component of the proposal in 2020.

The final component of the proposal are the 0.6 g/bhp-hr new engine and optional lower-emission standards and again assumes the “All LSI Equipment” inputs from Table 6.0. The high estimate assumes the difference between a 2.0 g/bhp-hr standard and a 0.6 g/bhp-hr standard, while the low estimate assumes a difference between a 1.0 g/bhp-hr standard and a 0.6 g/bhp-hr standard.

The calculated 2020 emission benefit of this proposal falls about 10 percent short of the ARB’s SIP commitment. However, as discussed in Section 5, the 2010 standards are somewhat conservative and do not fully incorporate readily available automotive emissions control technology. Staff will revisit the potential and need for future standards once the current standards have been fully implemented and after the impacts of LPG fuel quality have been evaluated.

6.2 Other Impacts

ARB staff has also assessed the impacts from the use of electric forklifts. An increase in their use would result in a corresponding increase in the electrical energy required to recharge the batteries on a regular basis and in turn, create a greater demand for electricity at generating facilities. The ARB is aware of the energy supply shortage that existed in California in the spring and summer of 2001.

To determine the relative impact from the use of electric forklifts, staff assumed that the population of Class 1 electric rider forklift trucks grew by 25 to 50 percent as a result of the regulation. Staff assumed that these electric forklifts had an average of 50 horsepower (37.3kW) and would be operated at a 30 percent load factor for 1,900 hours per year. Under these assumptions, the increased energy demand from the additional entire electric forklift fleet would be approximately 0.05 to 0.10 percent of the projected total energy demand in 2010. This increased demand, which includes losses associated with the distribution of electricity, will not have a significant impact on the overall system.

The use of electric forklifts will increase electricity demand and subsequently upstream emissions, primarily NOx, from power plants. The NOx emissions from power plants attributed to the increased energy demand of electric forklifts will be small in comparison to the NOx emissions from the LSI forklifts that are being replaced. Additionally, air district permitting programs are in place to minimize these emission increases and previous estimates have determined these upstream emissions to be extremely small compared to the benefits achieved.

While electrification of forklifts will result in the increased production and use of batteries, lead-acid batteries are well regulated and banned from municipal solid waste landfills. Additionally, California has an established recycling infrastructure, and the recycle rate for lead-acid batteries is currently over 95%. With these mitigation measures in place, battery disposal impacts should not be significant.

7 ECONOMIC IMPACTS – COST AND COST-EFFECTIVENESS

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

State agencies are also required to estimate the cost or savings to any state, local agency and school district in accordance with instructions adopted by the Department of

Finance. The estimate shall include any non-discretionary cost or savings to local agencies and the cost or savings in federal funding to the state.

Any business involved in the production or use of LSI engines would potentially be affected by the proposed regulation. Also potentially affected are manufacturers that supply components for engines and industrial equipment, and distributors and retailers that sell such equipment.

7.1 Potential Impact on Manufacturers

The proposed engine standards will impact manufacturers of off-road LSI engines and original equipment using such engines. Engine manufacturers are located mostly outside of California. As manufacturers are already developing engines to comply with the federal 2.0 g/bhp-hr standard for 2007, the proposed alignment of the California standards for 2007 to 2009 are not expected to result in significant additional work or costs. For reference, the U.S. EPA estimates that the additional cost to manufacturers meeting the 2007 standards is approximately $50.

As noted in Section 4.4, engines meeting the 2.0 g/bhp-hr standard are equipped with the necessary hardware to meet the 2010 requirement of 0.6 g/bhp-hr through calibration modifications. Even so, to provide a conservative cost analysis, ARB staff assumed that 25 percent of all engines would need improvements to the catalyst system (increased volume and/or precious metal loading) resulting in average hardware cost increases of 40 percent. This cost, as shown in Table 7.0, relies on the costs and assumptions contained within the U.S. EPA's rulemaking for 2007.

Table 7.0: Incremental Hardware Cost

	per engine
Base catalyst/muffler	$229
Markup (@ 29%)	$66
Total	$295
Improved catalyst/muffler	$320
Markup (@ 29%)	$92
Total	$415
Incremental cost (for the 25 percent of engines needing improvements)	$120
Average incremental cost	**$30**

Spreading the cost of the catalyst upgrade to all engines sold in California reduces the average incremental per engine cost to $30 for all engines meeting the 2010 standard.

The U.S. EPA analysis determined the fixed and variable costs for manufacturers producing LPG, CNG and gasoline engines to meet the 2.0 g/bhp-hr standard. ARB staff used the compliance costs from this analysis to determine the engineering and compliance costs for engines certified to the 0.6 gram standard. The incremental hardware costs noted above were then included to determine the overall cost presented in Table 7.1. As shown, the proposed new standards for 2010 are expected to add less than $100 to the cost of a new engine. This cost will be passed onto the fleet operator and is small enough to not significantly impact California competitiveness, employment or business status.

Table 7.1: Incremental Costs for the 2010

	per engine
Research and development	$20
In-Use Testing	$10
Certification	$20
Hardware improvements	$30
Total Incremental Cost	$80

The compliance costs in Table 7.1 assume that manufacturers will produce and sell most 0.6 g/bhp-hr engines nationwide and thus be able to spread the fixed costs over a larger volume of engines. The ARB staff believes that this is reasonable given that the engines expected in 2010 are essentially the same as those produced to meet the federal regulations. ARB staff did not, however, assume that the 25 percent of engines with more expensive and robust catalysts would be sold nationwide. Therefore, the per engine certification cost considers that these engines are only sold in California, and thus is greater than the per engine estimates presented by U.S. EPA.

The research and development costs in Table 7.1 reflect the calibration changes needed to meet the 2010 standards. A portion of the in-use testing cost derived by U.S. EPA is due to facility upgrades for transient testing to meet the federal 2007 standards. As these improvements will occur regardless of this proposed rulemaking, the in-use testing cost assumed by ARB staff is conservative.

7.2 Potential Impact on Distributors and Dealers

Most engine and equipment manufacturers sell their products through distributors and dealers. While distributors and dealers are not directly affected by the proposed standards, the proposed standards may affect them indirectly. An increase in price could potentially reduce sales. ARB staff believes that the proposed regulation is unlikely to cause significant impacts to dealers. The increase in cost is expected to be modest (less than 1 percent) and will be passed on to end-users since all competing equipment will increase in price.

7.3 Potential Impact on Equipment Operators

Under the staff proposal, fleets would have the flexibility to decide the mix of options to achieve the required fleet average emission levels. The fleet average approach will allow LSI fleet users to choose the lowest cost option for their particular application. Among the possible options are retrofit equipment, early purchase of certified cleaner equipment or purchase of zero emission electric equipment. To determine a range of potential cost, staff analyzed the potential impact to end users of the requirements applicable to fleets of different sizes. Consistent with the emission benefit analysis presented in Section 6, staff calculations incorporated the forklift input factors of the OFFROAD Model: a 64 horsepower engine operating 1,800 hours per year at a 30 percent load.

7.3.1 Lower-emission Engines

Staff believes that several manufacturers are well-positioned to offer lower-emission engines consistent with, or even better than, the scenarios presented in Section 4.2.1. ARB staff has assumed that there will be slight increases in hardware costs to produce lower-emission engines in advance of the proposed standards. As presented in Section 7.1, the additional hardware costs are expected to be average $30 per engine.

To determine cost-effectiveness, ARB staff based the benefits on equipment designed to meet the 0.6 g/bhp-hr standard. The emissions benefit, based on the forklift input factors of the OFFROAD Model is approximately 110 pounds per lift per year.

7.3.2 Retrofit

Retrofit systems provide emission reductions from older uncontrolled forklifts producing 12 g/bhp-hr HC+NOx to a level of 3.0 g/bhp-hr HC+NOx or lower. The cost of a retrofit system is estimated to be $3,000 installed (Lubrizol, 2005; Precision Governors, 2005). Staff expects that the cost may drop due to increased sales volume from this program. However, using $3,000 as a conservative value, these systems provide a typical benefit of approximately 690 pounds of HC+NOx reductions per forklift per year. It should also be noted that many of the 2001 through 2003 engines that were certified as uncontrolled during the phase in of the 3.0 g/bhp-hr standard already have some of the emission control components. Lower cost retrofit systems could be available for these engines.

The installation of a retrofit system will improve engine operation and reduce fuel use. Closed-loop fuel systems generally operate close to stoichiometry, improving the engine's efficiency. Information from retrofit control system manufacturers and data from the U.S. EPA indicates an estimated 10 to 20 percent reduction in fuel consumption with engines employing fuel management systems (U.S. EPA, 2002). For a typical LPG or gasoline forklift, the annual fuel savings for forklifts used in California will range from $800 to $1,200. Thus, the retrofit of existing uncontrolled engines can actually reduce overall costs. Table 7.2 provides an example of these fuel savings.

Table 7.2: Estimated Fuel Savings

	LPG
Horsepower	64
Load factor	0.30
Improved brake-specific fuel consumption (pound/hp-hour)	0.075
Fuel density (pound/gallon)	4.2
Fuel cost ($/gallon)	1.50
Annual savings	$930

7.3.3 Zero-Emission

A typical electric forklift may cost anywhere from $1,500 to 5,000 more than a comparable LSI forklift (EPRI, 2001). However, electric forklifts have a longer useful life and reduced fuel and maintenance costs compared to LSI forklifts, so they can actually be less expensive on a life-cycle basis, especially for those fleets that do not need to utilize the forklift for multiple shifts in a single day.

Electric forklifts can provide emission reductions from 2.0 g/bhp-hr to 12.0 g/bhp-hr depending on the level of equipment they replace. Assuming an average emission reduction of 7.0 g/bhp-hr and the same LSI horsepower, hours of use, and load factor as noted above yields an average emissions reduction of 500 pounds per year.

7.3.4 Incremental Capital Cost

Table 7.3 summarizes the estimated initial costs of each option available to fleet operators. These values were used to generate the estimated cost effectiveness presented below. It should be emphasized that there are significant life cycle benefits from the use of retrofit and zero-emission equipment due to reduced fuel and maintenance costs, both of which have the ability to more than pay for themselves over their life.

Table 7.3: Incremental Capital Cost

Compliance Option	
Retrofit	$3,000
Lower-Emission	$30 - $80
Zero-Emission	$1,500 - $5,000

7.4 Cost-Effectiveness

The capital cost estimates in Section 7.3 were amortized over the expected life of the equipment[3] with an interest rate of five percent. The amortization formula yields a capital recovery factor, which when multiplied with the initial capital cost, gives the annual cost of the compliance option over its expected lifetime. Dividing the annual cost of the compliance option by the emissions benefit in pounds for that option yields the cost-effectiveness. For both retrofit and electric forklifts, the cost-effectiveness is presented as range to reflect both the full incremental capital costs and the overall lifecycle costs.

For those businesses that can incorporate electric equipment without the need for battery-swapping or fast-charging, staff believes electric equipment provides a life cycle saving, as described in Section 4.1.1. However, many businesses are sensitive to the initial capitol costs, therefore the cost-effectiveness is also listed with the full capital cost. Staff did not estimate the full life-cycle cost of electric equipment if fast-charging or battery swapping were necessary. Because the proposed fleet average requirement provides flexibility, staff assumed that an operator would not choose to convert to electric equipment unless the operator could be reasonably and cost-effectively incorporate such equipment within the fleet or had other reasons for doing so.

Table 7.4: Cost-Effectiveness

Compliance Option	Dollars per pound
Retrofit	0 – 1.00
Lower-emission	0.13
Zero-Emission	0 – 1.40[1]

1. Cost-effectiveness based on replacement of both controlled and uncontrolled equipment.

Thus, as illustrated in Table 7.5 above, fleet operators have several cost-effective options to comply with the fleet standards. The cost-effectiveness for all options compares favorably with other regulatory programs adopted by the Board.

7.5 Potential Impact on Business Competitiveness, Employment, Business Creation and Elimination

The proposed regulation is not expected to have a significant impact on the ability of California businesses to compete with business in other states. Requirements for end users are not expected to be significant as new engines, electric equipment and retrofit kits all provide performance and cost benefits. The resale value of existing uncontrolled equipment that is not retrofitted will be reduced.

[3] Conservatively, the expected life of a retrofitted forklift is 5 years, while that of a lower-emission forklift is 7 years and an electric forklift is 9 years.

The proposed regulation is not expected to cause a noticeable change in California employment. California accounts for only a small share of the manufacturing employment in industrial equipment and components. Requirements for end users are not expected to be significant as new engines, electric equipment, and retrofit kits all provide performance and cost benefits.

The proposed regulations are not expected to cause any significant change in the status of California businesses. The regulation would potentially increase the retail price of LSI equipment. However, these costs are expected to be minor. The regulation will stimulate demand for fuel system components and retrofit systems, resulting in an increase in business for some California manufacturers.

8 PUBLIC OUTREACH AND ENVIRONMENTAL JUSTICE

Outreach and public participation are important components of ARB's regulatory development process. In preparing the proposed regulations, ARB staff developed an outreach program to involve LSI engine and equipment manufacturers and distributors, emission control system manufacturers, propane fuel refiners and distributors, end-user facility operators, federal regulatory agencies, environmental/pollution prevention and public health advocates and other interested parties.

Through these efforts, ARB staff has been able to obtain detailed information on the use and emissions from LSI equipment. Additionally, these entities participated in the development and review of the manufacturers advisory correspondence (MAC) for voluntary early certification of lower-emission engines, the interim retrofit verification procedure for retrofit emission control systems and the baseline survey for uncontrolled agricultural equipment.

As part of the outreach efforts, ARB staff made extensive personal contacts with industry and facility representatives as well as other affected parties through meetings, telephone calls, and mail-outs. These activities included:

- holding five public workshops;
- the formation of the off-road LSI equipment working group;
- 20 conference calls with the working group to discuss our activities;
- more than 100 telephone conversations with the working group and facility operators;
- electronic mailing, or making available on the ARB web site, working group agendas, minutes, draft proposals;
- electronic mailing of workshop notices to over 500 people on the LSI list serve;
- visiting 15 facilities to gather information on the type of equipment and the building parameters that would limit the use of zero-emission alternative equipment.

8.1 Environmental Justice

The ARB is committed to integrating environmental justice in all of its activities. On December 13, 2001, the Board approved "Policies and Actions for Environmental Justice," which formally established a framework for incorporating Environmental Justice into the ARB's programs, consistent with the directive of California state law. Environmental Justice is defined as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.

The proposed regulation is consistent with the environmental justice policy to reduce health risks by limiting criteria pollutants in all communities, including those with low-income and minority populations, regardless of location. The regulation will reduce HC+NOx emissions from all new and most uncontrolled in-use engines by requiring the use of the best available control technologies or by limiting the number of uncontrolled engines or their hours of operation. The proposal will provide air quality benefits for all communities proportional to the number of pieces of LSI equipment currently operating in those communities.

9 ADDITIONAL CONSIDERATIONS

9.1 Fuel Quality

Liquefied petroleum gas is a mixture of various hydrocarbons produced from crude oil refining or the processing of natural gas. Propane is the predominant component of LPG. LPG used for motor vehicles must meet a quality specification to ensure proper operation of motor vehicles and to achieve and maintain exhaust emission standards. LPG fuel that does not meet these motor vehicle specifications can harm engine fueling systems and components and can prevent an engine from complying with existing and future emissions standards.

In 1992 the ARB established motor vehicle fuel specifications for LPG limiting the propene content to 10% by volume. Other heavier hydrocarbons are also limited. Not all LPG produced meets the LPG motor vehicle specifications. LPG not meeting the motor vehicle specification is considered commercial grade propane and is used mostly for space heating and recreational purposes.

There are two separate concerns about the LPG motor vehicle fuel quality - fuel contamination and high olefin content. Contaminated fuel can have an immediate and sometimes catastrophic impact on the fuel delivery system and the emissions control system. Contamination typically occurs downstream of production during storage and distribution. One example of contamination can occur from fuel hose degradation.

There is information to suggest that LPG containing high olefins, such as propene, can accumulate on fueling components and can adversely affect the fuel delivery and emission control systems. This accumulation is often the result of using commercial grade fuel in motor vehicles. Commercial grade fuel is intended primarily for heating, and has a higher olefin content than motor vehicle grade LPG. Olefins react to create a plastic-like coating in the vaporizers, carburetors, and injectors. This coating gums up these engine components, reducing the effectiveness of heat transfer and ultimately causing poor delivery of the fuel and inaccurate fuel to air ratios. Heavy hydrocarbon residue may also cause similar problems.

The ARB is committed to working with industry to determine if the existing specifications are adequate to support more stringent emission standards. The ARB will take the necessary steps to ensure that quality fuel is available to support existing and future LPG-fueled vehicles including developing appropriate specifications, if necessary.

The ARB is also following activities by the control device manufacturers, refiners and LPG distributors to make low olefin LPG fuel, advanced fuel filters, and fuel additives available to fleets, leading to reduced emissions and vehicle maintenance and improved fuel efficiency.

9.2 Impact on Rental Companies

Some of the largest owners of larger LSI fleets are forklift dealers. A high percentage of forklifts in use today are rented by end-users from these same dealers. For these dealers a large amount of their assets, debt and overall net worth is tied up in their rental fleets. In some cases, these fleets contain a significant percentage of relatively new uncontrolled LSI equipment. The proposed fleet requirements may impact the forklift dealers as fleet users are expected to request lower-emission compliant forklifts to meet their fleet average. Consequently, it may be more difficult to lease uncontrolled LSI equipment for any leases that continue through 2009.

Retrofit control systems provide added value to the owner because they provide significant savings in fuel costs that pay for the retrofit within four years. In addition, for those owners that apply early, retrofit costs could be mitigated through Carl Moyer incentive funds.

9.3 Agricultural Concerns

ARB staff has worked with agricultural-related businesses to discuss issues specific to that industry. After evaluating data on equipment age, type and use, ARB staff and industry representatives worked together to develop a proposal that provides greater flexibility. ARB staff believes this proposal is responsive to the specific needs of the industry. While the proposed regulation would allow additional time for compliance, the most significant issue remaining is to what extent the fleet operators would be eligible for incentive funds such as the Carl Moyer Program.

The most cost-effective approach to meet the proposal is to retrofit existing equipment. Agricultural fleets would be eligible for funding for retrofits systems if applied in advance of the regulations. However, manufacturers of retrofit systems have indicated that the use of these systems on older equipment is questionable. For older equipment, several factors decrease the feasibility of retrofit, including the general state of the equipment, economy of scale to offer reasonably priced kits and value of the equipment relative to the cost of performing a retrofit. As such, it is unlikely that a good portion of the uncontrolled agricultural fleet will lend itself to retrofit. Consequently, agricultural operations that own the equipment will have to either repower or replace their equipment. Public incentive programs are not currently designed to provide assistance under these scenarios. However, ARB staff will continue to explore opportunities to reduce the overall costs to comply with the proposal.

9.4 UL Concerns

Underwriters Laboratories (UL) is an independent, not-for-profit, product-safety testing and certification organization. Their reputation for certifying the safety of machinery, equipment and consumer products is known worldwide. UL's Listing Service is the most widely recognized of UL's safety certification programs. The UL Listing Mark on a product is the manufacturer's representation that samples of that complete product have been tested by UL to nationally recognized Safety Standards and found to be free from reasonably foreseeable risk of fire, electric shock, excessively high surface temperatures, and related hazards.

During development of the first LSI regulation, several equipment manufacturers informed staff that their customers expect, and in cases require, the equipment they purchase to be UL listed. These manufacturers expressed concern that the presence of catalytic converters could make it difficult to meet UL requirements for fire safety and safety from exposure to high temperature surfaces. They also expressed concern about the expense of conducting the tests required by UL.

In response, staff discussed the issue with UL personnel. UL stated that they do certify catalysts, and that their catalytic converter requirements limit the temperatures of surfaces located adjacent to a muffler or catalytic converter, while maintaining the converter's structural capability to contain backfire pressures, etc. They also stated that certification may be conducted directly through testing of the complete converter and equipment configuration, or, alternatively, through testing of the converter as a component in a reference installation. UL's Component Recognition Service covers the testing and evaluation of component products that are incomplete or restricted in performance capabilities. These components will later be used in complete end products or systems Listed by UL. The reference installation usually represents a worst-case scenario in terms of engine size, converter proximity to sensitive surfaces, etc. The component evaluation ensures that all requirements (temperature, etc.) are met in that reference installation. The equipment manufacturer would then need to demonstrate to UL, through engineering evaluation, that its application is similar to, or inherently safer than, the reference installation. This process minimizes the actual testing for UL listing and shares the costs and responsibility for the listing between the equipment manufacturer and the catalytic converter manufacturer. Catalyst manufacturers have stated that this process will minimize the costs associated with obtaining a UL listing.

During this rulemaking, manufacturers again expressed concerns about their ability to meet UL requirements, this time as a result of retrofit emission control systems – typically comprised of a catalytic converter and an electronic air/fuel control. Staff again spoke with UL personnel and hosted a conference call where manufacturers were provided an opportunity to question UL about the specific requirements for obtaining a UL Listing Mark for a retrofit emission control system. As before, UL personnel stated that the system could be certified and that the certification could be conducted directly through testing of the complete retrofit emission control system and equipment configuration, or, alternatively, through testing of the control system as a component in a reference installation (UL, 2004). If a retrofit emission control system manufacturer opts for the latter, then a UL evaluation of the complete product could be needed to determine how this component functions as part of the overall system. However, the use of Recognized Components reduces the complexity of the evaluation and can save the manufacturer time and money.

10 ALTERNATIVES AND RECOMMENDATION

10.1 Alternatives Considered

During the regulatory development process, ARB staff evaluated many tools and identified the following as having the most promise to reduce emissions from LSI engines.

- Lower Manufacturer Emission Standards
- Manufacturer Fleet Average Standards
- Owner or User Fleet Average Standards
- Near-Zero Emission Requirements
- Zero Emission Requirements
- In-Use Retrofit Requirement

Each of the elements noted was considered both independently and in combination. At one point, ARB staff pursued the requirement for electric purchase. This concept would have required medium and large fleets to meet a 10 percent electric component in 2007, 20 percent in 2008, 30 percent in 2009, and 40 percent in the years 2010 through 2015. ARB staff decided this concept would not provide the necessary flexibility to industry in meeting the requirements.

ARB staff also considered requiring that medium and large fleets reduce emissions from their existing uncontrolled LSI engines by the end of 2008 through the use of retrofit emission control systems. Small fleets of one to three units would have been provided until 2010 to retrofit their equipment, and would have been exempt from the electric purchase requirement. Again, staff rejected this concept and instead developed a fleet average concept to allow fleets options for reducing fleet emissions.

10.2 Conclusion

The proposal described herein would reduce HC+NOx emissions in a cost-effective manner. No alternative considered by the agency would be more effective in carrying out the purpose for which the regulation is proposed or would be as effective or less burdensome to affected private persons than the proposed regulation.

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APPENDIX A: PROPOSED STANDARDS

1. Proposed Regulation Order, Part 1: Amend California Code of Regulations, Title 13, Sections 2430, 2433, and 2434 for Off-Road Large Spark-Ignition Engines.

2. Proposed Regulation Order Part 2: Adopt California Code of Regulations, Title 13, Sections 2775, 2775.1, and 2775.2 for Large Spark-Ignition (LSI) Engine Fleet Requirements.

3. Proposed Regulation Order Part 3: Amendments to the incorporated "California Exhaust and Standards and Test Procedures for New 2001 and Later Off-Road Large Spark-Ignition Engines," and Adoption of incorporated "California Exhaust and Standards and Test Procedures for New 2007 and Later Off-Road Large Spark-Ignition Engines."

APPENDIX B: VERIFICATION PROCEDURE

1. Proposed Regulation Order Part 4: Adopt California Code of Regulations, Title 13, Sections 2780, 2781, 2782, 2783, 2784, 2785, 2786, 2787, 2788, and 2789 for Verification Procedures for Retrofit Systems Verification Procedure, Warranty, and In-Use Compliance Requirements for Retrofits to Control Emissions from Off-Road Large Spark-Ignition Engines.

2. Verification Process Flowchart

3. Verification Testing Flowchart