CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
AIR RESOURCES BOARD

STAFF REPORT: NEW EMISSION STANDARDS, FLEET REQUIREMENTS, AND TEST PROCEDURES FOR FORKLIFTS AND OTHER INDUSTRIAL EQUIPMENT

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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, the vast majority of Californians live in areas of the state that still do not meet State or federal health-based ambient air quality standards. Clearly, ozone – or smog – continues to be a serious health problem throughout much of our state. The California Air Resources Board (ARB or Board) pursues emissions reductions from all feasible sources in order to continue our progress toward clean air and to meet and sustain our air quality goals.

In 1998, the ARB first adopted emission standards for new spark-ignited engines used in propane forklifts and other similar industrial equipment. These engines are referred to as large spark-ignition (LSI) engines. In addition to forklifts, the LSI category includes airport ground support equipment (GSE), sweepers and scrubbers, generator sets, small irrigation pumps, and a variety of other similar equipment. The full implementation of these first emissions standards in 2004 required engine manufacturers to achieve approximately a 75 percent reduction in smog-forming pollutants. This was done with the incorporation of basic emissions control technology that had been successfully used in passenger cars for more than 20 years.

The 75 percent reduction was an important step, but still left the level of control for these new engines relatively basic. Building on this success, the United States 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 from new engines were technically feasible and cost-effective.

In developing the ARB's 2003 State Implementation Plan (SIP) for Ozone, it became clear that additional emissions reductions were possible from not only new LSI engines, but also in-use LSI equipment. The regulation of in-use LSI equipment represents an enormous opportunity since each uncontrolled forklift has the same emissions per day as over 700 clean passenger cars. Currently, there are over 30,000 uncontrolled forklifts in California. The Board-adopted SIP included a commitment to achieve additional reductions from the LSI category of between 6.1 and 13.0 tons per day of hydrocarbons (HC) and oxides of nitrogen (NOx) statewide by 2010. This proposal is designed to meet that 2003 obligation.

In June 2005, the ARB presented an initial LSI proposal to the Board. At that time, questions arose about the economic impact of the in-use portion of the proposal on forklift dealers and agricultural-related businesses that could not be fully answered. In addition, several stakeholders asked for more time to work with staff on its regulatory proposal. Accordingly, the Board listened to staff's presentation and to public testimony but deferred action to a later date. Subsequent to the June 2005 hearing, ARB staff has had numerous meetings and telephone conversations with dealer and agricultural

business representatives in order to better understand their business practices and the economic impacts of the proposal.

The current proposal is similar to the June 2005 proposal, but revises several key modifications based on these meetings and ARB staff's subsequent analysis. The modifications are designed to reduce the economic impacts on agricultural businesses and address the unique business practices of forklift dealers. The main elements of this proposal are highlighted below, along with the key revisions to the previous proposal.

In late 2002, air carriers operating in the South Coast air basin signed a memorandum or understanding (MOU) with ARB committing to reduce HC and NOx emissions from new and in-use GSE used in airport operations. The MOU was intended to address the air carriers' contributions to the air basin's extreme ozone nonattainment classification. The airlines terminated the MOU on October 28, 2005. To retain those benefits, staff is proposing that GSE fleets in the South Coast air basin meet the same fleet average emission requirements as other fleets, and meet the zero-emission requirement of the MOU applied to the LSI fleet.

Proposed Requirements

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 rigorous test procedures and on-board diagnostics.
- More stringent emissions standards for 2010 and later model-year engines.
- Optional lower-emission standards to give manufacturers more flexibility.

Requirements for Fleet Users

- Fleet average emission limits for operators of specific LSI equipment (forklifts, sweeper/scrubbers, industrial tow tractors, and airport ground support equipment) beginning in 2009.
- An alternative compliance option for agricultural fleets to address issues specific to the agricultural industry.

Verification Procedure for Manufacturers of Retrofit Control Systems

- A new procedure for verifying LSI retrofit emission control systems.

Key Modifications to the June 2005 Proposal

For Equipment Dealers

Small fleets (one to three units) are no longer covered by the proposal. This modification reduces the in-use emissions benefit of staff's earlier proposal by less than 20 percent (roughly one ton per day of HC+NOx in 2010) while exempting an estimated 60 percent of fleets (the very smallest ones) from the fleet rules. This change not only eases the burden on small users, but also provides an ongoing purchaser pool for dealers that have uncontrolled equipment coming off existing leases. The primary concern with staff's 2005 proposal was that it was believed to impose unreasonably high control costs on relatively low-value equipment coming off lease. The proposed exemption for small fleets solves that problem while still controlling the majority of in-use engines.

For Agriculture

The alternative agricultural proposal would require control of only those owned forklifts for which a verified retrofit system is commercially available (40 percent of current agricultural forklifts). In addition, the timeframe for compliance provides an opportunity for 80 percent of this equipment to be eligible for Carl Moyer Program incentive funds if the owners act quickly to install retrofits. The proposal would allow those forklifts for which retrofit systems are not available to continue to operate, avoiding the cost of replacement. With full use of incentive funds, the modification reduces the cost by approximately 90 percent while retaining over one ton per day HC+NOx benefit during the summer ozone season.

For Air Carriers

Special requirements applicable to commercial airlines operating airport GSE in the South Coast air basin that implement provisions of a recently terminated MOU.

Economic and Environmental Impacts

The proposed 2007 new engine emission standards are not expected to create significant economic impacts because engine manufacturers are already developing engines to comply with the federal 2007 standards. The proposed California standards for 2010 and later can be met by optimizing emission controls used to meet U.S. EPA's 2007 standards, and thus provide extremely cost effective emission reductions estimated at $0.13 per pound.

In general, in-use fleet rules provide significant opportunities for emissions reductions but also require careful consideration due to their possible economic impacts on owners and users of the equipment. In many ways, the LSI category is well-positioned to achieve in-use emissions reductions. Available retrofit technology reduces emissions by 75 to 90 percent and is cost-effective. Because emission standards for new engines

have been in effect only for the past few years, a significant number of high-emitting, uncontrolled equipment is still in operation and available for retrofit. Operators can meet the proposed in-use fleet-average emission standards by procuring low- and zero-emission equipment and by retrofitting uncontrolled equipment in their fleets. The use of new controlled engines and the retrofit of existing engines can reduce fuel use and improve engine life, creating cost savings that offset a portion of the additional equipment cost. As a result, the fleet requirements are cost-effective and range from $0.13 per pound for lower-emission equipment to $1.40 per pound for electric equipment.

The proposed in-use fleet-average emission standards will result in additional costs for some dealers of LSI engines. The costs depend on the number and age of the uncontrolled equipment in their possession, the rate at which they currently turn-over old equipment, the extent to which additional costs can be passed along, and the ability to sell equipment to small fleets that are exempt from the proposed regulations. This latter provision significantly reduces the economic impact of the proposal on dealers.

The ARB staff proposal will reduce statewide HC and NOx emissions by 5.7 tons per day in 2010 and 6.2 tons per day in 2020. These reductions are near or within the range of the commitment established within the 2003 SIP.

Staff Recommendation

The ARB staff recommends that the Board adopt the amendments as set forth in the proposed Regulation Order in Appendices A, B, and C and as described in this Initial Statement of Reasons.

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1 INTRODUCTION

The California Clean Air Act, adopted in 1988, grants the Air Resources Board (ARB) the authority to regulate a wide variety of off-road mobile engines and equipment. These sources include, but are not limited to marine vessels, locomotives, utility engines, off-road motorcycles, and off-highway vehicles. Forklifts, and other off-road large spark-ignition (LSI) equipment, are a subcategory of off-road mobile equipment subject to ARB regulation. Approximately 88,000 pieces of LSI equipment exist in California, with current hydrocarbon (HC) and oxides of nitrogen (NOx) emissions of approximately 15 and 54 tons per day, respectively.

In addition to forklifts, off-road LSI equipment includes 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. Forklifts comprise roughly half of the LSI inventory and contribute more than 85 percent of the category's emissions. The basic engines used in off-road equipment are similar to, and typically derived from, automobile engines, although they have significantly fewer emissions controls. They 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, and fully implemented in 2004. The proposed amendments in this rulemaking continue ARB's efforts to achieve additional cost-effective reductions from the category. Requirements are proposed that would provide significant near- and mid-term reductions by addressing the remaining high-emitting uncontrolled equipment in-use. The proposal would also provide significant mid- and long-term reductions by establishing more stringent new engine HC and NOx emission standards in 2007 and 2010. Finally, the proposal would allow engine manufacturers to certify to optional lower-emission standards, and provide retrofit equipment manufacturers a test procedure for certifying retrofit systems.

In late 2002, the ARB signed a memorandum of understanding (MOU) with air carriers to reduce HC and NOx emissions from ground support equipment (GSE) in the South Coast air basin. The MOU included provisions for the early introduction of clean units, with a requirement for an average 2.65 grams per brake-horsepower hour HC+NOx fleet. The MOU also called for a specified percentage of zero-emission equipment and the use of diesel oxidation catalysts and diesel particulate filters to significantly reduce particulate matter emissions from the diesel portion of the fleet.

1.1 Regulatory Authority

As noted above, the ARB has been granted the authority to regulate emissions from off-road mobile sources. The authority, however, does not extend to new equipment under 175 horsepower used primarily in construction or farm equipment or vehicles. The United States Environmental Protection Agency (U.S. EPA) has sole authority to control

emissions from this equipment, i.e., California is preempted from regulating this equipment. In the LSI category, the preempted equipment includes welders, air compressors, and irrigation pumps. Because of this preemption, some emissions from the subject engine category are beyond ARB's authority to regulate. However, the ARB staff works closely with the U.S. EPA in their development of federal rules to cover all engines in this category. It should be noted that the preemption does not prohibit the ARB from regulating a piece of equipment under 175 horsepower that is used in construction or farming; instead, it prohibits the ARB from regulating *categories* of equipment that are *primarily* used in construction and farming. The ARB has established a list of the types of equipment that are not primarily used in construction or farming. All equipment over 25 horsepower but less than 175 horsepower is considered to be construction or farm equipment except for the 11 categories listed below.

- 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

1.2 Applicability

The new engine emission standards discussed in Section 3 apply to engines greater than 19 kilowatts (25 horsepower) used in the 11 categories of equipment listed above. The in-use requirements apply only to users of forklifts, sweeper/scrubbers, industrial tow tractors and GSE. Examples of GSE include forklifts, tugs, belt loaders, bobtails, cargo loaders, lifts, air conditioners, service trucks, de-icers, fuel delivery trucks, and ground power units.

Diesel equipment is not subject to the requirements of this proposal. Instead, separate requirements for in-use diesel forklifts are being developed and are expected to be proposed in late 2006.

1.3 Outreach

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 engage LSI engine and equipment manufacturers and distributors, emission control system manufacturers, propane fuel refiners and distributors, end-user facility operators, agricultural interests, federal regulatory agencies, environmental organizations, public health advocates, and other interested parties.

Through these efforts, ARB staff has been able to obtain detailed information on the use of, 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 and the interim retrofit verification procedure for retrofit emission control systems.

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, forming an LSI regulatory working group and holding 20 conference calls with the working group, more than 100 telephone conversations with the working group and facility operators, and visiting more than 15 facilities.

In June 2005, ARB presented a similar LSI proposal to the Board. At that time, questions arose about the impact of the proposal on forklift dealers and agriculture-related businesses that could not be fully answered and the Board took no action. In response, the ARB staff has conducted a series of meetings with both stakeholder groups, focusing on better understanding their business operations. This more detailed analysis has allowed staff to better understand the potential economic impacts to these two stakeholder groups. The current proposal is similar in structure to the previous proposal, but revises several key provisions in response to these discussions and analyses.

2 CURRENT REGULATIONS AND INVENTORY

2.1 California LSI Regulation

In 1998, ARB adopted LSI regulations in collaboration with U.S. EPA. The regulations phased-in an emission standard for new engines of 3.0 grams per brake-horsepower-hour (g/bhp-hr) of HC and NOx beginning in 2001.

2.2 Federal LSI Regulation

Federal law preempts California from regulating engines less than 175 horsepower used primarily in farm and construction equipment. To address these engines, the ARB staff worked closely with U.S. EPA in its development of a nationwide federal rule to cover all new engines in this category. The federal rule, adopted in 2002, established nationwide emission standards for new LSI engines, including those used in farm and construction equipment. The U.S. EPA regulation requires that LSI engines nationwide meet the same 3.0 g/bhp-hr standard beginning in 2004 as required in California. The federal regulation also includes a more stringent standard: beginning in 2007, new LSI engines must meet a 2.0 g/bhp-hr standard using a more rigorous transient testing procedure. It additionally contains evaporative emission and in-use requirements that were not included in the 1998 California regulation. As a result of the State and federal

regulations, new LSI engines are now 75 percent cleaner than uncontrolled LSI engines and will become even cleaner beginning in 2007.

2.3 2003 State Implementation Plan for Ozone

LSI equipment accounted for approximately six percent of all off-road emissions in 2000 and this percentage is increasing (ARB, 2003). 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 a passenger car certified to California's cleanest standard emits during its entire life. Yet, 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 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 new engine emission standard. The second measure proposed that emissions from existing or in-use LSI engines be reduced by 80 percent or to a 3.0 g/bhp-hr verification level. The proposed verification protocol provides a range of percentage reductions from 75 percent to more than 90 percent based on the state of technology. The latter measure also proposed that new standards be developed that reflected the availability of zero- and near-zero-emission technologies.

2.4 Airport Ground Support Equipment Memorandum of Understanding

In late 2002, air carriers operating in the South Coast air basin signed a MOU with ARB committing to reduce HC and NOx emissions from new and in-use GSE used in airport operations. The GSE performs a variety of functions, including: starting aircraft, aircraft maintenance, aircraft fueling, transporting cargo and passengers to and from aircraft, loading cargo, baggage handling, lavatory service, and food service.

The GSE MOU was developed in cooperation with the Air Transport Association (ATA; representing the major South Coast air basin's air carriers), the Federal Aviation Administration, U.S. EPA, and the South Coast Air Quality Management District. It was intended to address the air carriers' contributions to the air basin's extreme ozone nonattainment classification. The MOU included provisions for the early introduction of clean units, with requirements for a 2.65 grams per brake-horsepower hour HC+NOx fleet average at the five major airports in the South Coast air basin by December 31, 2010, and the use of diesel oxidation catalysts and diesel particulate filters to significantly reduce particulate matter emissions from the diesel portion of the fleet. The MOU also included a requirement to have electric or zero-emission vehicles represent at least thirty percent of the 1997 existing fleet, in aggregate, by December 31, 2010. The signatory airlines terminated the MOU on October 28, 2005 stating that the

adoption of the Portable Engine Air Toxic Control Measure and other pending rulemaking that affects GSE is generally statewide in approach and largely inconsistent with the MOU, which is applicable only in the South Coast.

The staff proposal presented in Section 3 is intended to retain the benefits of the original MOU through 2010 and achieve slightly greater benefits by 2013.

2.5 LSI Inventory

The ARB's OFFROAD emission inventory model (ARB, 1998b), adopted in 1998 and updated regularly, was used in the development of this rulemaking. The annual average statewide emissions from off-road LSI engines are shown in Table 2.0. Off-road LSI equipment emitted about 70 tons per day of HC and NOx in 2004. By 2010, the emissions of these pollutants will be reduced to about 35 tons per day. This decrease is due to the new engine emission standards implemented in 2001. The trend, while positive, does not produce the same degree of reduction achieved from some other off-road categories.

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

Year	Population	HC	NOx
2004	87,687	15.4	54.8
2010	92,104	7.5	28.3
2020	96,964	4.4	19.0

[1] The inventory shown in Table 2.0 includes engines preempted by federal regulations. The emissions estimates do not reflect the impact of U.S. EPA's 2007 new engine emission standard.

The three equipment categories in Table 2.1 contribute the majority of off-road LSI emissions and are the focus of the regulatory proposal to reduce emissions from in-use fleets. As calculated from Table 2.1, emissions from these three categories account for greater than 80 percent of the total statewide LSI emissions in 2004. In terms of population, in 2004, the categories account for 60 percent of all off-road LSI equipment.

Table 2.1: Off-Road LSI Equipment Emissions
Top Three 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 GSE	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

3 REGULATORY PROPOSAL

Staff has worked with LSI engine and equipment manufacturers and distributors, emission control system manufacturers, propane fuel refiners and distributors, end-user facility operators, federal regulatory agencies, air carriers, environmental groups, and other interested parties since January 2004 to identify approaches that would reduce emissions from new and in-use LSI engines and equipment. The most promising options involved lower-emissions standards for new engines, and fleet emission limits applicable to in-use fleets. Staff conducted workshops in May and August 2004 on these approaches. A proposal combining both approaches was discussed at two workshops held in March 2005 and presented to the Board in June 2005. Pursuant to the Board's direction, additional information was sought and the proposal was further revised.

A central element of the proposed regulation is a fleet-average emission standard applicable to equipment operators. The requirement would reduce emissions from uncontrolled equipment through retrofit and/or replacement with newer, lower-emission or electric equipment. More stringent emission standards for new engines ensure that cleaner LSI equipment would be available for purchase. The elements of the proposal are discussed below.

3.1 More Stringent Emission Standards for New Engines

The proposed emission standards for new engines include the following components: adoption of U.S. EPA's 2007 model-year emission standard, a more stringent 2010 model-year emission standard, optional certification standards and more rigorous test procedures.

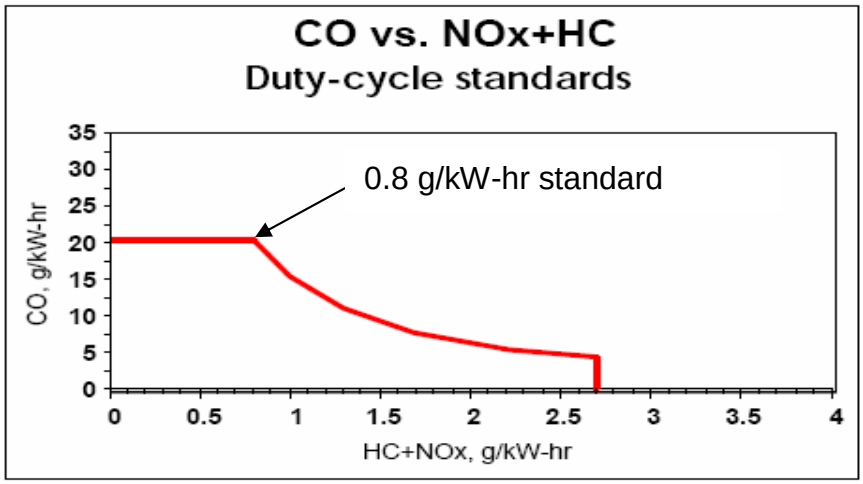
3.1.1 2007 Standard

Beginning with the 2007 model year, U.S. EPA's tailpipe emission standards for new LSI engines are more stringent than ARB's adopted standards. Staff proposes to adopt the U.S. EPA standards so that they can be enforced by California. Engine manufacturers would be required to meet a 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 standards. Alternatively, a manufacturer could certify to the following formula:

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

This formula, established by U.S. EPA, is represented by the curve shown in Figure 3.0. The alternative certification standard provides manufacturers with the flexibility to certify engines with higher CO emissions if they achieve lower HC+NOx levels. Staff believes such a tradeoff is protective of public health.

Figure 3.0: Alternative Federal Certification



3.1.2 2010 Standard

Staff proposes a more stringent emission standard for new 2010 and subsequent model-year engines of 0.6 g/bhp-hr (0.8 g/kW-hr) HC+NOx and 15.4 g/bhp-hr (20.6 g/kW-hr) CO. The proposed standards lie on the alternative compliance curve, as show by the arrow in Figure 3.0. Stated another way, the proposed 2010 standard limits the calibration flexibility of the engine manufacturer to achieve the lowest feasible HC+NOx emission level. For the 2005 model year, eight engine families used in industrial applications emitted at levels at or below the proposed 2010 standards.

3.1.3 Optional Certification Standards

The staff also proposes to establish optional emission standards that are numerically lower than the 2007 and 2010 mandatory standards. During model years 2007 through 2009, engines could be certified to the optional new engine standards of 0.1, 0.2, 0.4, 0.6, 1.0, or 1.5 g/bhp-hr HC+NOx. For model year 2010 and beyond, engines could be certified to optional standards of 0.1, 0.2, or 0.4 g/bhp-hr HC+NOx. A January 20, 2005, Manufacturers Advisory Correspondence already allows manufacturers to certify their current engines to these interim lower-emission standards.

The optional standards provide manufacturers that produce cleaner engines an opportunity to certify at a lower standard. This may translate into a product that is available for Carl Moyer Program incentives. It may also be a more desirable product for the fleet owner that must meet an in-use fleet-average requirement.

3.1.4 Enhanced Test Procedures and Other Manufacturer Requirements

The U.S. EPA emissions standards that take effect in 2007 also include more rigorous certification requirements and test procedures. This proposal adopts by reference the U.S. EPA certification and testing requirements for the 2007 to 2009 model years, and,

with minor revisions, those requirements that begin in the 2010 model-year, as described in Appendix A, parts 4 through 7. The revisions include production line testing and in-use compliance procedures.

The ARB staff also proposes to adopt the new U.S. EPA requirements for evaporative emissions and for engine-diagnostics systems.

3.2 In-Use Emission Standards

The ARB staff is proposing that operators of large and mid-size fleets of forklifts, sweeper/scrubbers,[1] GSE and industrial tow tractors meet an average emission standard for their in-use fleet. 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. The requirements would begin January 1, 2009.

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 reflecting the greater availability of zero- and low-emission technologies.

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 factors, 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. A detailed discussion of the various compliance scenarios identified by ARB staff can be found in Appendix B.2. The following table summarizes the proposed fleet average emission levels for forklift and non-forklift LSI fleets.

[1] With engine displacement greater than one liter. Of the engines certified in the 2004 model year for sweeper/ scrubbers, 46 percent had a displacement of one liter or less (ARB, 2005). Engines with less than one liter displacement are not subject to the LSI proposal and the equipment containing them is not subject to the fleet average requirement.

Table 3.0: In-Use Fleet Average Emission 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)	2.7 (3.4)	2.5 (3.6)
Small fleet	1-3	Exempt from Fleet Requirements		

The fleet average proposal provides additional flexibility to the fleet operator that increases its fleet size enough to jump from one category to the other by instituting two-year transition periods that correspond with the fleet average compliance dates. For example, on January 1, 2009, a mid-size fleet would have to meet a 2.6 g/bhp-hr standard. If that same fleet, through growth, becomes a large fleet, they would not have to meet the 2.4 g/bhp-hr requirement. However, they would have to meet the 1.7 g/bhp-hr requirement for large fleets, beginning on January 1, 2011, as that is the next fleet requirement.

3.2.1 Special Fleet Requirement for GSE in the South Coast Air Basin

On October 28, 2005, ATA notified ARB that the air carriers who had signed the MOU were terminating the GSE MOU. The termination became effective 60 days later, December 27, 2005. The terminated MOU included a 2.65 g/bhp-hr HC+NOx fleet-average standard for the LSI and diesel fleets, and a requirement that 30 percent of the baseline fleet be zero-emitting. Staff is proposing that GSE fleets in the South Coast air basin meet the same fleet-average emission requirements as other LSI fleets, and meet the MOU's zero-emission requirement for their current fleet.

3.2.2 Small Fleet Exemption

The ARB staff recognizes that small fleets, with one to three pieces of equipment, are least able to absorb the costs of an in-use proposal. In addition, it is believed that these users, in general, use their equipment fewer hours per year than the large- or mid-size fleets. Initially in considering these factors, the staff proposed that small fleets meet a relaxed requirement, consisting of two additional years to comply, relative to other fleets, and a less stringent fleet-average requirement. This was part of the proposal presented to the Board in June 2005.

Staff has since revised its proposal to exempt fleet operators of three or fewer LSI engines. The exemption reduces the number of fleets subject to the rule by as much as 60 percent while reducing the emission benefit by less than 20 percent. As discussed in Section 6.3, a substantial portion of the inventory of some forklift dealers is uncontrolled.

The cost of retrofit or disposal of a large number of forklifts imposes a large cost on these dealers compared to other fleet operators whose cost of operating forklifts is only a small portion of revenues. Thus, the small fleet exemption reduces the cost of compliance for forklift dealers by providing a sales outlet for some uncontrolled forklifts currently in their inventory.

3.2.3 Hours of Use Exemption

Low-use equipment may be temporarily 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 meet at least Level 2 verification as described in Section 3.3.1 below or by 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.

3.2.4 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 permanently 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 of the hours of use exemption (see Section 3.2.3 above).

3.3 Proposed Verification Procedures for Retrofits

The ARB staff is proposing a procedure to verify the in-use emission performance of retrofit control systems that can be used to help meet the proposed fleet-average emission requirements. The proposed verification procedures (contained and described in Appendix C) would apply to manufacturers of retrofit systems sold in California. These systems include but are not limited to, closed-loop fuel-control systems, fuel-injection systems, and three-way catalysts.

3.3.1 Retrofit Emission Verification Levels

Table 3.1 presents the LSI retrofit system verification levels that a manufacturer could choose. 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. In addition, the proposed procedures allow retrofit technologies that reduce emissions from either uncontrolled engines or certified engines. These options provide flexibility for manufacturers to develop a variety of control systems and determine the appropriate level of emission control for each.

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 verified emissions reduction is 25 percent regardless of actual emission test values
[3] The verified percentage reduction for LSI Level 2 is 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

At the time of the June 2005 hearing, ARB staff believed that the majority of retrofit systems would be verified to Level 2, providing a 75 percent reduction from 12 g/bhp-hr to 3.0 g/bhp-hr. Comments from manufacturers indicated that the applicability of the system would likely be limited to equipment that was approximately 1996 or newer. Since then, however, the ARB has verified a retrofit system that brings uncontrolled 12 g/bhp-hr equipment to a level that is cleaner than current new equipment – down to 1.0 g/bhp-hr. In addition, this system is applicable to the majority of all forklifts as old as 1990. Two additional retrofit systems are now in the process of being verified. The verified system is now available for many pieces of uncontrolled equipment.

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

Recognizing that forklift fleets owned and used in agricultural crop-preparation services are often significantly older than other fleets, and that these businesses are often not in a position to fully recover costs, ARB staff is proposing an alternative compliance option for these fleets.

In June 2005, staff presented an option for fleets owned by agricultural crop-preparation businesses that was less stringent than the basic fleet requirement and allowed

additional time for compliance. Nonetheless, concern has continued regarding the cost of the proposal, especially the costs related to replacing equipment that could not be retrofitted. Staff has revised its proposal to further reduce costs by only requiring compliance of owned forklifts for which retrofit kits are available, thus avoiding the higher cost of replacing or retiring forklifts.

About 40 percent of the forklifts owned by agricultural-related business are expected to have retrofits commercially available and be subject to retrofit; the remaining forklifts would not be affected by the proposal. Specifically, owners of agricultural-related fleets would be required to reduce emissions (to a 3.0 g/bhp-hr level or less) of 20 percent of their equipment for which retrofits are available by January 1, 2009, and the remaining 80 percent by January 1, 2012. In addition, the agricultural proposal includes a low hours-of-use exemption and specialty equipment exemption, similar to those in the basic fleet average requirement. However, the low hours-of-use equipment exemption is permanent.

The economic impact of this alternative proposal is described in Section 6.5 and the emissions benefits achieved (and foregone) from this proposal are detailed in Section 5. In summary, the proposal will result in substantially reduced costs to operators of agricultural forklifts, and provide an opportunity to receive incentive funds. The agricultural summer ozone season emission benefit of the proposal is approximately one ton per day of HC+NOx by 2012, which is 1.5 tons per day less than if full applicability were sought.

4 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.

4.1 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 oxygen 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 fuel injection. Today's advanced systems maintain an extremely tight stoichiometric air-to-fuel balance during nearly all engine operations. This is important because fluctuations from stoichiometric result in reduced efficiency in controlling HC, NOx, and CO emissions.

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 emissions by more than 95 percent.

4.2 Emission Controls for LSI Engines

Current LSI engines use closed-loop fuel-control systems with three-way catalysts to meet State and federal emission standards. The components used, however, are generally cheaper and less effective than versions found in passenger cars. Even so, close to 50 percent of all LSI engines certified in 2004 emitted at 1.0 gram or less which is well below the 2007 2.0 grams per brake-horsepower-hour standard. In addition, several current LSI engines already emit at 0.5 grams or less, demonstrating the feasibility of the more stringent 2010 standards. Engines tested and evaluated by U.S. EPA were used to establish the curve shown in Figure 3.0, which has an endpoint of 0.8 g/kW-hr. Many of the engines being certified to meet the 2007 standard are expected to also be able to meet the 2010 standard through calibration changes alone. For others, modest improvements in precious metal loading, higher cell densities, and/or more effective washcoats may be needed. These technologies are readily available from the automotive sector.

4.3 Impact of Transient Testing

Some manufacturers have expressed concerns about the impact of the 2007 transient test cycle on the feasibility of achieving the proposed new engine standards. 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 emissions from 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. Clearly, the new test cycle does not prevent compliance with the proposed 2007 standard.

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 proposed 2007 standard (SwRI, 2004). The proposed 2010 standard requires a 70 percent emission reduction. Given that several current production LSI engines emit well below the proposed standard and the exceptionally low emission levels demonstrated on modern passenger cars, meeting the proposed 2010 LSI standard is feasible.

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

4.4 Lead Time

When U.S. EPA promulgated the federal LSI standards, the Agency stated that 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. The U.S. EPA went on to state the expectation that the emission-control technologies for the 2004 emission standard would be able to meet the 2007 standard with additional optimization and testing. The ARB's staff expects that three years will also be sufficient time for manufacturers to further optimize the emission-control technologies needed to meet the 2010 ARB 0.6 g/bhp-hr requirement. It also provides sufficient time to incorporate hardware changes, should they be necessary.

4.5 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. The 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 may prevent an engine from complying with existing and future emissions standards.

In 1992, ARB established motor vehicle fuel specifications for LPG limiting the propene content to 10 percent by volume. Other heavier hydrocarbons are also limited. Not all LPG produced meets the LPG motor vehicle specifications. The 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 LPG motor vehicle fuel quality - fuel contamination and high olefin content. Contaminated fuel can have an immediate and sometimes damaging impact on the fuel delivery system and the emissions control system. Contamination typically occurs downstream of production during storage and distribution. For example, 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 is executing a

contract to analyze 150 LPG samples from various sites statewide. The ARB is also following activities of 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.

5 ENVIRONMENTAL IMPACTS

5.1 Air Quality Impacts

Staff used the ARB's OFFROAD model to estimate emissions from LSI engines. The key assumptions for population and activity are shown in Table 5.0.

Table 5.0: OFFROAD Model Input Factors

Input	Unit	All LSI Equipment[1]
Horsepower	hp	63
load factor	unitless	0.47
activity	hours/year	905
2010 population	unitless	92,507
2020 population	unitless	96,963
life	years	10.8

1 Population-weighted

Staff calculated the emission benefit from the introduction of the 0.6 g/bhp-hr low emission standard using the difference between that standard and the federal 2.0 g/bhp-hr standard, new equipment sales volume, and the above input standards. Staff calculated the emission benefit from the fleet-average requirements by taking the difference between an established baseline fleet-average emission level and the proposed fleet-average emission levels for all affected fleets. The baseline takes into consideration the current use of electric equipment in many fleets.

Table 5.1 lists the 2010 and 2020 emission benefits of the proposed regulation. The in-use benefits are roughly 20 percent lower than those presented at the June 2005 Board hearing. The reasons for the decrease in emission benefit are shown in Table 5.3.

Table 5.1: Statewide Emissions Benefits

Staff Proposal Element	HC+NOx Reductions (tons per day)	
	Year 2010	Year 2020
Fleet Average Emission Requirements[1]	4.5	< 1.0[2]
New Engine Standards	1.2	6.2
Total	5.7	6.2

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

2 The benefits from the in-use standards are expected to be minimal in 2020 as the vast majority of the equipment will have been retired.

Table 5.2 shows the estimated 2010 and 2020 benefits of the staff's proposal for the South Coast relative to the SIP emission reduction commitment for that region. The benefits in the South Coast are expected to decrease in proportion to the statewide decrease, but will still represent 46 percent of the statewide total. As shown in Table 5.2, the emission benefits of staff's revised proposal are just below the 2003 SIP commitment for 2010 and well within the range for 2020.

Table 5.2: South Coast Air Basin Emissions Benefits

	HC+NOx Reductions (tons per day)	
	Year 2010	Year 2020
2003 SIP Commitment	2.8 -6.0[1]	1.5 – 5.1
Staff's Proposal	2.6	2.9

1 6.1 to 13.0 tons per day on statewide basis.

The staff's revised proposal contains provisions to reduce the costs to small fleets and agricultural-related businesses. The effect of these revisions is to reduce the emission benefit achieved in the post-2010 time-frame. The reduced benefits of the small fleet exemption does not impact the 2003 SIP commitment for 2010 because small fleets were not originally required to have their equipment comply with prescribed standards until 2011. It additionally is not reflected in the 2003 SIP commitment for 2020 because it is assumed all uncontrolled forklifts (except agricultural forklifts), will have been retired by that time.

The proposal for agricultural-related businesses is estimated to achieve 1.3 tons per day for the summer ozone season by 2012. The substantial portion of the previous and current agricultural proposal occurred after 2010, therefore the 2010 benefits are not significantly impacted by this revision. By 2020, staff assumes that 40 percent of the agricultural-related forklifts will have been retired, reducing the emissions loss to about 1.0 ton per day. Table 5.3 shows the impacts from these revisions.

Table 5.3: Impact of Revised In-Use Proposal
(tons per day HC+NOx)

Agriculture Retrofit Only[1]	(2.2)
Small Fleet Exemption	(1.0)

1 The agricultural benefits are for the summer ozone season, assuming that 75% of annual hours occur during this period.

It should be noted that dealers have questioned whether the existing LSI regulations have already achieved emission benefits not reflected in staff's inventory because a significant number of LSI engines are certifying well below the standards. The emission benefits attributable to the LSI regulations already in effect were determined using the applicable certification standards consistent with the methodology for most other mobile source regulations. The ARB staff will continue, nonetheless, to assess and improve the LSI emissions inventory, including in-use emissions, and other factors such as hours of use, emissions deterioration, and equipment life.

5.2 Other Impacts

The 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, would create a greater demand for electricity supplied at generating facilities.

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 consequent 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 percent. With these mitigation measures in place, battery disposal impacts should not be significant.

6 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 costs or savings to any state or local agency and school district in accordance with instructions adopted by the Department of Finance. The estimate shall include any non-discretionary costs or savings to local agencies and costs 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.

6.1 Incentive Programs

Incentive programs have the ability to prompt emissions benefits early or beyond those required by regulations. California has the largest incentive program in the nation, with over $140 million available each year through State and local funds. Even so, this level of funding is far from sufficient to pay for all the reductions needed to provide clean air. Reductions required by regulations, and funded by owners of the affected equipment, will still provide the majority of emission reductions.

Currently, incentive programs, such as the Carl Moyer Program, provide modest funding for forklift projects. In some cases, the incremental cost of electric forklifts can be funded (about $5,000) if the applicant can demonstrate he or she is not in an occupation where electric forklifts are the norm. Purchase of low-emission forklifts has not previously been an eligible category because no low-emission standards existed (“low-emission standards” refers to optional standards more stringent than otherwise required of all LSI engines). With the adoption of the proposed optional low-emission standards, manufacturers could be eligible for the incremental cost of the low-emission equipment. Recently, retrofit systems for forklifts have become an eligible project category, with the full retrofit cost eligible for funding.

With the adoption of the proposed regulation, most of the incentive projects would no longer be eligible for funding. Several exceptions would remain:

Small Fleets

Small fleets, from one to three units, are exempt from the regulatory proposal. As such, they would continue to be eligible for incentive funding. Eligible projects include the incremental cost to purchase electric forklifts, low-emission forklifts, and retrofits.

Agricultural-Related Fleets

The alternative proposal for agricultural-related businesses would not require implementation of the retrofit requirements until January 1, 2012, for 80 percent of these fleets. As such, that portion of the fleet would be eligible for incentive funds to pay the full cost of the retrofit through January 1, 2009. After that point, the project could not demonstrate a three-year project life, as required by the Carl Moyer Program.

Complying Fleets

Fleets that demonstrate full compliance with their fleet-average requirements would be eligible for incentive funds to further reduce emissions. Eligible projects would include electric forklifts, low-emission forklifts, and retrofits.

6.2 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 adoption of California standards for 2007 to 2009 is not expected to result in significant additional work or costs. For reference, the U.S. EPA estimates that the additional cost to manufacturers of meeting the 2007 standards is approximately $50 per engine.

Most engines meeting the 2.0 g/bhp-hr standard are expected to use the same basic hardware to also meet the 2010 requirement of 0.6 g/bhp-hr, although calibration changes will be needed. 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 an average hardware cost increase of 40 percent. This cost is shown in Table 6.0. U.S. EPA's rulemaking for 2007 is the source for the base catalyst cost.

Table 6.0: Incremental Hardware Cost
2010 Emission Standard

	per engine
Base catalyst/muffler (2 gram standard)	$295
Improved catalyst/muffler (0.6 gram standard)	$415
Incremental cost (for the 25 percent of engines needing improvements)	$120
Average incremental cost	**$30**

Spreading the cost of the catalyst upgrade across all engines sold in California results in an average incremental per engine cost of $30.

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. The ARB staff used the compliance costs from this analysis to determine the engineering and compliance costs for engines designed to meet the 0.6 gram standard. The incremental hardware costs noted above were then included to determine the overall cost presented in Table 6.1. 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 6.1: Incremental Retail Price Equivalent Costs
To Meet 2010 Standard

	per engine
Research and development	$20
In-Use Testing	$10
Certification	$20
Hardware improvements (from Table 6.0)	$30
Total Incremental Cost	$80

The compliance costs in Table 6.1 assume that manufacturers will produce and sell most 0.6 g/bhp-hr engines nationwide (the 75 percent that do not require extra hardware to comply) and, thus, will 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 to be in production in 2010 are essentially the same as those that will be 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, the cost is greater than the per engine estimates presented by U.S. EPA.

The research and development costs in Table 6.1 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 used by ARB staff is conservative.

6.3 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. Dealers earn income through the sale and lease of new forklifts, parts and service for in-use forklifts, forklift rental, and the sale of used forklifts. In the June 2005 proposal, staff believed that forklift dealers would be able to pass through the vast majority of all costs associated with the proposal to the operators of the equipment. Since that time, staff has learned that the business model for forklift dealers is more complex. The following discussion assesses how the various elements of the staff proposal may affect dealers.

Regarding the sale or lease of new forklifts, this proposal is not expected to have a significant positive or negative impact on dealers. An increase in price could potentially reduce sales. However, the projected increase in cost is modest (less than 1 percent) and it is expected that it will be passed on to end-users since all competing equipment will increase in price. It is more likely that an impact of the proposal will be that fleets will turn over equipment more quickly in order to comply with the fleet-average requirements. This would result in the increased sale and lease of new equipment.

In the sale of parts and service for in-use equipment, the proposal is likely to have a slightly positive impact since the proposal would result in increased business to install retrofit systems in order to comply with the fleet-average requirement.

With regard to rental forklifts, the proposal would require that forklifts rented for less than one year meet a 3.0 g/bhp-hr emission standard by 2009. The impact on the dealers would depend on several factors, including when the dealers began purchasing controlled equipment, the average turn-over rate of their rental fleet, and the ability to pass along any increased rental costs due to more expensive equipment. A dealer that was receiving controlled equipment since 2003 and is on a five-year lease turn-over cycle would not have any significant impact. A number of dealers are in this position. Most dealers, however, will have a small percentage of uncontrolled equipment still within their rental fleet by 2009. A few dealers were still receiving uncontrolled equipment in 2004 and if they are on a longer turn-over cycle may have to address a larger percentage of their fleet.

A dealer may employ several options to address the uncontrolled fleet. A straightforward option is to install a retrofit system. The cost of the retrofit system to the dealer and its installation are estimated to be $3,500. The extent to which these costs may be passed along to the rental customer is unknown. Dealers have stated that they do not believe any increase in costs could be passed along because they have not been able to increase rental costs for many years. However, in the new dynamic of a fleet rule, it seems reasonable to assume that some increase in costs could be accommodated. Staff does not believe the full cost could be recouped.

A second option for the dealer would be to slightly accelerate the turn-over of the rental fleet to incorporate new or used equipment that is controlled. Again, this would require added costs on the part of the dealership for a portion of the fleet, and it is unclear what percentage of that cost could be passed along. A related option is for dealers to adjust the make-up of their rental fleets. The revised staff proposal would allow uncontrolled equipment to be sold to small fleets. Therefore, dealers could guide uncontrolled equipment to small business sales and ensure more controlled equipment is moved into the rental fleet. A third ption is for dealers to utilize the low-hours exemption. As discussed, equipment that is used less than 250 hours per year would have two additional years to comply.

None of these solutions fits all the situations or provides the entire solution. Those dealers with some uncontrolled equipment remaining in their rental fleet will likely need to incorporate several of the options in order to comply with the regulations in the most cost-effective way. In addition, dealers will need to be prepared to make adjustments to how they currently conduct business in order to maintain a fleet of controlled equipment available to rent.

The final income source for dealers is used forklift sales. A number of dealers have portrayed this source of income as providing the largest profit for the dealership. In order for dealers to have an ample supply of used forklifts coming back to them for resale, dealers often guarantee the value of any new lease that they enter. Consequently, the fleet rule, as structured in the June 2005 proposal, could have had a significant economic impact on some dealers, since it would have devalued the uncontrolled equipment for which they had guaranteed a specific value. Staff believes the current proposal significantly reduces, although does not eliminate this impact. The proposed exemption of small fleets from the in-use fleet requirement will provide a continuing market for uncontrolled forklifts. However, not all used dealer forklifts are sold to small fleets.

Table 6.2 provides a range of potential costs to dealers. The total number impacted is based on information from industry and is largely affected by normal turnover and placement of equipment in small fleets. The cost range assumes that a large portion of the equipment procured in 2004 was uncontrolled, that all equipment impacted will be retrofit at a cost of $3,500 per unit, and that none of the cost is passed along to the consumer. These assumptions provide a worst-case analysis for the industry as a

whole. As shown in the table, staff estimates the total cost to be between roughly $2 million to $5 million. Rather than retrofitting the forklifts, dealers may avoid this cost by limiting their sales of uncontrolled equipment to small fleets and selling the equipment over a longer period of time.

Staff's June 2005 proposal did not include the small fleet exemption and would have impacted this segment of uncontrolled forklifts. Since a large percentage of equipment is ultimately sold into small fleets, the June 2005 proposal would have represented two to three times the estimated costs presented in Table 6.2 below.

Table 6.2: Potential Costs to Dealers[1]
Revised Staff Proposal

Total Impacted - low estimate	250 units
- high estimate	1,400 units
Cost per Retrofit	$3,500
Total Cost to Equipment Dealers	$875,000 to $4,900,000

1 Dealers estimated a total of approximately 12,000 forklifts statewide. Based on a typical lease life of 5 years and typical rental life of 5-8 years, and an estimate of 85 percent of forklifts sold to small fleets, the low and high estimates were derived for the number of uncontrolled forklifts.

6.4 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, 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.

6.4.1 Lower-Emission Engines

Fleet operators can purchase new engines as necessary to meet the fleet standards. Incremental costs for engines in the 2007 to 2009 timeframe are attributable to federal regulations that will require equipment to meet the 2.0 g/bhp-hr standard. For engines purchased in 2010 and beyond, staff expects that the incremental cost will be minimal, less than $100. Fleet operators may also be able to buy optional, lower emission engines. The incremental costs for these engines is not known, but these costs are not expected to be significant as some engines already being sold emit at these low levels.

6.4.2 Zero-Emission

An electric forklift typically costs from $1,500 to $5,000 more than a comparable LSI forklift (EPRI, 2001). However, since an electric forklift has a longer useful life and reduced fuel and maintenance costs, the electric forklift can reduce life-cycle costs compared to a LSI forklift.

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

6.4.3 Retrofit

Retrofit systems reduce emissions from older, uncontrolled forklifts, which produce 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 $3,500 as installed (Lubrizol, 2005). These systems provide an average 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 are already equipped with 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 U.S. EPA indicate an estimated 10- to 20-percent reduction in fuel consumption with engines employing closed-loop systems (U.S. EPA, 2002). For a typical LPG or gasoline forklift, the annual fuel savings from a retrofit system used in California is estimated at $600 as shown in Table 6.3. Thus, the retrofitting of existing uncontrolled engines can provide net savings over the equipment's life.

Table 6.3: Estimated Fuel Savings

Input	LPG
Horsepower (hp)	66
Load factor (unit-less)	0.30
Use (hours)[1]	1,200
Improved brake-specific fuel consumption (pound/hp-hour)	0.075
Fuel density (pounds per gallon)	4.2
Fuel cost (dollars per gallon)	1.50
Annual savings (dollars)	600

1 The fuel savings estimate is based on an annual usage of 1,200 hours as opposed to the average use-rate of 1,800 hours to reflect the fact that older equipment is used less than the average.

6.4.4 Incremental Capital Cost

Table 6.4 summarizes the estimated initial costs of each option available to fleet operators. These values were used to generate the estimated cost effectiveness

presented below. Staff did not include in its calculation the reduced fuel and maintenance costs resulting from use of retrofitted and zero-emission equipment, which over the equipments' life may exceed the incremental capital cost.

Table 6.4: Incremental Capital Cost

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

6.5 Potential Impact on Agriculture

The proposed regulations include an alternative compliance option for forklifts owned by agricultural fleets to address issues specific to that industry. This option reduces costs to agricultural businesses to a minimal level.

Applying the fleet average proposal to agricultural-related fleets results in a total cost to industry of over $30 million. Staff identified this as a concern, and prior to the June 2005 Board hearing staff developed a proposal that significantly reduced the cost and spread it over 10 years. Staff estimated that the June 2005 proposal would have a cost of between $5 million and $6 million. At that time, industry estimated the cost to be significantly higher. The main differences were that staff assumed a modest level of turnover and industry assumed no turnover. In addition, staff assumed industry would purchase used forklifts when replacing an old forklift, and industry assumed new forklifts would be purchased.

Staff has revised its proposal for agricultural-related fleets. Equipment for which a retrofit system is available must be retrofit. Equipment for which no retrofit system is available may continue to be used. This avoids the higher cost of replacing this typically older equipment, which would have been required under staff's June 2005 proposal.

Based on the information provided by the agricultural industry, uncontrolled forklifts that can be retrofitted and thus would be impacted by staff's revised proposal account for 40 percent of their total owned forklifts. Assuming a conservative 10 percent of the affected forklifts will take advantage of one of the two exemptions proposed (low-use, specialized equipment), only 830 forklifts will be required to be retrofitted. Table 6.5 presents the total costs, and the estimated cost to industry if the fleets take full advantage of the incentive monies that are available under the revised proposal.

Table 6.5: Potential Costs to Agriculture

Equipment	2,300 units
Equipment Impacted[1]	830 units
Cost per Retrofit	$3,000 - $4,000
Total Capital Cost	$2.5-$3.3 million
Eligible for Financial Assistance	80 percent
Potential Net Cost	$500,000-$660,000

1 As estimated by industry, 40 percent of the fleet is model-year 1990 or newer and can be controlled. 10 percent of this portion of the fleet is assumed to meet the low usage or specialty equipment exemption.

On a per fleet basis, a typical business such as a packinghouse might have between 10 and 20 owned forklifts potentially impacted by this proposal. Of those, between four and eight would be required to have a retrofit. Incentive funding could be available for up to 80 percent of these. If the typical packinghouse takes advantage of maximum incentive funding and only needs to fund two retrofit systems, the cost to the packinghouse could be as low as $6,000 to $8,000. If incentive funding is not utilized, maximum cost would be in the range of $32,000. For simplicity, the cost estimates do not incorporate fuel savings that the retrofit systems provide.

6.6 Cost-Effectiveness

The incremental capital cost estimates in Section 6.4.4 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 retrofitted and electric forklifts, the cost-effectiveness is presented as a range to reflect both the full incremental capital costs and the overall life-cycle 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. However, as many businesses are sensitive to the initial capital costs, 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 reasonably and cost-effectively incorporate such equipment within the fleet or had other reasons for doing so.

[3] Conservatively, the expected life of a retrofitted forklift is five years, while that of a lower-emission forklift is seven years and an electric forklift is nine years.

Table 6.6: Cost-Effectiveness

Compliance Option	Dollars per pound
Retrofit	0 – 1.20
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 6.6 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 ARB.

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

The proposed regulation is not expected to have a significant impact on the ability of California businesses to compete with businesses in other states. Requirements for the 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.

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.

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.

7 ALTERNATIVES AND RECOMMENDATION

7.1 Alternatives Considered

In June 2005, ARB staff presented a proposal that was similar in structure to the current proposal, except that it retained a fleet average requirement for small fleets and a more aggressive alternative option for agricultural-related businesses. The June proposal achieved greater reductions; however, staff believes the economic impact of that proposal was too high. The current proposal provides a more appropriate balance between technical feasibility and cost to affected industries.

During the regulatory development process, ARB staff evaluated various strategies for reducing emissions from LSI engines including:

- Lowering Manufacturer Emission Standards
- Manufacturer-based Fleet-Average Standards
- Owner or User Fleet-Average Standards
- Near-Zero Emission Requirements
- Zero-Emission Requirements
- In-Use Retrofit Requirements

Each of the elements noted was considered both independently and in combination. At one point, ARB staff actively pursued a 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, and might force the use of a specific technology in applications where it would be unsuitable.

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 had additional time to retrofit their equipment, and would have been exempt from the electric purchase requirement. Again, staff rejected these concepts and instead developed a fleet average concept to allow fleets greater flexibility in reducing their emissions.

7.2 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 as or less burdensome to affected private persons than the proposed regulation.

REFERENCES

ARB, 1998a. "Public Hearing to Consider Adoption of Emission Standards and Test Procedures for New 2001 and Later Off-Road Large Spark-Ignition Engines," California Air Resources Board, September 4, 1998.

ARB, 1998b. "Notice of Public Meeting to Consider the Approval of California's Off-Road Large Spark-Ignited Engine Emissions Inventory," California Air Resources Board, October 22, 1998.

ARB, 1998c. "Notice of Public Meeting to Consider the Approval of California's Off-Road Large Spark-Ignited Engine Emissions Inventory," Attachment 1, Input Factors, California Air Resources Board, October 22, 1998.

ARB, 2001. "Policies and Actions for Environmental Justice. "Sacramento, California. California Air Resources Board, December 13, 2001.

ARB, 2003. "Proposed 2003 State and Federal Strategy for California State Implementation Plan," Section II Mobile Sources, Introduction and Chapter D, California Air Resources Board, August 25, 2003.

ARB, 2005a. California Air Resources Board, Large Spark-Ignition Off-Road Summary, 2005 Model Year Certified Large Spark-Ignition Engine List: http://www.arb.ca.gov/msprog/offroad/cert/search_result.php , undated web page.

ARB, 2005b. Cost-Effectiveness Calculations Spreadsheet, Air Resources Board, April 2005

ARB, 2006a. Criteria Pollutant Emission Benefits Spreadsheet, Air Resources Board, February 2006

ARB, 2006b. Agricultural-Related Emissions Analysis, Air Resources Board, February 2006

ARB, 2006c. Dealer Costs Spreadsheet, Air Resources Board, February 2006

EPRI, 2001. "Increasing Profits with Electric Industrial Vehicles: A Case Study on the Alabama Power Company Electric Forklift Incentive Program," Electric Power Research Institute Inc., 2001.

GRI, 1995. "Industrial Truck Market Analysis," Final Report (GRI-95/0422), page 12, Gas Research Institute, October 1995.

GSE MOU, 2002. "South Coast Ground Service Equipment Memorandum of Understanding," An agreement between the California Air Resources Board and 17 airlines, November 27, 2002

ITA, 2005. Regular Member Products (by Class and Lift Code), http://www.indtrk.org/products.asp?id=rmp , April 25, 2005.

Lubrizol, 2006. Email from Cesar Baumann of Lubrizol Engine Control Systems, February 2, 2006.

MECA, 2003. "Emission Control Systems for Spark Ignited Vehicles & Engines: From PZEVs to Clean Lawn Mowers," Manufacturers of Emission Controls Association presentation, May 2003.

MECA, 2004. "MECA Responses to ARB Questions Regarding Three Way Catalyst (TWC) Technology for LSI Applications," Manufacturers of Emission Controls Association, prepared by Dr. Joseph Kubsh, MECA Deputy Director, June 30, 2004.

Nett Technologies, 2006. Email from Wayne Borean, of Nett Technologies, February 2, 2006.

SwRI, 2004. "Investigation of LPG Fuel System Technologies and Fuel Composition Effects on Emissions," Presentation to the Industrial Truck Association Spring Meeting, Southwest Research Institute, March 23, 2004.

U.S. EPA, 2002. "Control of Emissions from Nonroad Large Spark-Ignition Engines, and Recreational Engines (Marine and Land Based); Final Rule," Federal Register, Volume 67, Number 217, pages 68242 - 68447, November 8, 2002.

APPENDIX A: MANUFACTURER STANDARDS AND TEST PROCEDURES

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: Amendments to the incorporated "California Exhaust Emission Standards and Test Procedures for New 2001 and Later Off-Road Large Spark-Ignition Engines" (40 CFR, Part 86, Subpart A)

3. Proposed Regulation Order Part 3: Amendments to the incorporated "California Exhaust Emission Standards and Test Procedures for New 2001 and Later Off-Road Large Spark-Ignition Engines" (ISO 8178)

4. Proposed Regulation Order Part 4: Adoption of incorporated "California Exhaust Emission Standards and Test Procedures for New 2007 through 2009 Model-Year Off-Road Large Spark-Ignition Engines" (40 CFR, Part 1048)

5. Proposed Regulation Order Part 5: Adoption of incorporated "California Exhaust Emission Standards and Test Procedures for New 2010 Model-Year and Later Off-Road Large Spark-Ignition Engines" (40 CFR, Part 1048)

6. Proposed Regulation Order Part 6: Adoption of incorporated "California Exhaust Emission Standards and Test Procedures for New 2007 Model-Year and Later Off-Road Large Spark-Ignition Engines" (40 CFR, Parts 1065 and 1068)

APPENDIX B: FLEET AVERAGE EMISSION LEVEL REQUIREMENTS

1. Proposed Regulation Order Part 8: Adopt California Code of Regulations, Title 13, Sections 2775, 2775.1, and 2775.2 for Large Spark-Ignition (LSI) Engine Fleet Requirements.

2. Fleet Average Compliance Scenarios

APPENDIX C: VERIFICATION PROCEDURE

1. Proposed Regulation Order Part 9: 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. Description of the Proposed Verification Procedures for Retrofit Emission Control Systems for Off-Road Industrial Engines