Draft Proposal to Reduce Emissions from Off-Road Large Spark-Ignition Equipment Greater Than 25 Horsepower

A. Introduction and Overview

The California Air Resources Board (ARB or the Board) is developing regulations to reduce emissions of hydrocarbons and oxides of nitrogen (HC + NOx) from off-road equipment with large spark ignition (LSI) engines of more than 25 horsepower. Typical applications for LSI engines include forklifts, sweepers, portable generators, and a variety of other off-road equipment powered by propane, gasoline, or natural gas. If adopted, the proposed regulations would apply to both LSI engine manufacturers as well as users of the equipment. The proposal is scheduled to be considered for adoption in January 2005.

As part of our public regulatory process, we will soon be conducting a workshop on a proposed draft regulatory concept. Staff will present the elements of the proposal and solicit comments and questions from affected parties. ARB staff developed the draft concept in consultation with a technical working group comprised of engine, equipment, and exhaust system retrofit kit manufacturers, propane fuel suppliers, and end users.

B. Background

The ARB is responsible for protecting public health and the environment in California from the harmful effects of air pollution. The ARB works in cooperation with 35 local air districts and the U.S. Environmental Protection Agency (U.S. EPA) on strategies to attain State and federal health-based ambient air quality standards. These strategies are then incorporated into State Implementation Plans or SIPs as formal control measures. The SIPs serve as roadmaps that demonstrate to the U.S. EPA how California plans to attain those air quality standards.

In November 1994, the ARB approved a SIP for ozone. The SIP identified several categories of off-road equipment including LSI equipment where significant opportunities existed to reduce emissions of oxides of nitrogen (NOx) and hydrocarbons (HC). NOx and HC emissions combine in the atmosphere to form ozone, and more than one-third of NOx emissions come from off-road vehicles.

Four years later, in 1998, the ARB adopted regulations requiring new LSI engines sold in California to be certified to a standard of 3.0 grams per brake horsepower-hour (g/bhp-hr) of HC+NOx. Those regulations were phased in between January 2001 and January 2004. The U.S. EPA later adopted an LSI regulation incorporating test information obtained from the development of the 1998 ARB LSI regulation. The U.S. EPA regulation requires all new LSI engines nationwide to meet the same 3.0 g/bhp-hr standard beginning this year and a 2.0 g/bhp-hr standard in 2007. The 2007 requirement also specifies a more rigorous testing protocol and in-use requirement.

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. As a result, staff cannot overlook the significant opportunities that exist to further reduce NOx emissions from LSI equipment.

First, LSI equipment accounted for almost nine percent of off-road emissions in 2000 and this percentage is increasing. Second, there are large numbers of uncontrolled LSI engines still in use. An uncontrolled engine can emit 12 or more grams per brake horsepower-hour of NOx, contributing significantly to the smog problems in California. To put this in perspective, a piece of LSI equipment with an uncontrolled engine, a forklift for example, can emit as much in three shifts as a new car certified to California's lowest emission level would emit over its entire life. Third, LSI engines are generally based upon automotive engine technology, and engine and emission control device manufacturers can incorporate advanced automotive-inspired emission control technologies into new and in-use LSI equipment that dramatically reduce engine emissions while still meeting the operational needs of industries. Finally, zero-emission forklifts are available to provide even greater benefits.

In recognition of these emission reduction opportunities, the 2003 SIP included two measures for LSI engines. The first measure, LSI-1, proposed that California harmonize with the 2007 U.S. EPA 2.0 g/bhp-hr emission standard. The second measure, LSI-2, proposed that existing LSI engine emissions be reduced by 80% or to a 3.0 g/bhp-hr verification level. It also proposed that zero and near-zero emission standards be developed for new LSI engines.

C. Applicability

Typical applications for off-road LSI engines include forklifts, scrubber/sweepers, specialty vehicles, portable generators, large turf care equipment, irrigation pumps, welders, air compressors, airport service vehicles, and a wide array of other agricultural, construction and general industrial equipment. The engines used in this equipment often are derived from automobile engines, though they currently use less sophisticated fuel and emission control systems. Most commonly, gasoline or liquefied petroleum gas (LPG) fuels engines in this category. They are typically liquid-cooled engines, but some air-cooled engines remain in use. Similarly, most engines, particularly those derived from automobile engines, tend to use overhead-valve designs, although some use the mechanically simpler side-valve design.

This proposal addresses new and in-use off-road LSI equipment greater than 25 horsepower and a displacement of one liter or more. Off-road LSI equipment with engines greater than 25 horsepower, but a displacement of less than one liter has been regulated as small off-road equipment (SORE). Staff is proposing that these engines continue to be regulated under the SORE regulations.

Farm and construction equipment of 175 horsepower or more would be subject to the requirements of the proposal. Examples of LSI farm equipment include some tractors, combines, sprayers, swathers, agricultural pumps and wind machines. Examples of construction equipment include LSI bore/drill rigs, cranes, rough terrain forklifts, and other construction equipment. This proposal does not impact diesel-powered farm or construction equipment.

This proposal also does not address new farm and construction equipment under 175 horsepower because the U.S. EPA has sole authority to control emissions from this equipment. This federal preemption precludes California from regulating about twelve percent of the new equipment in this category. In-use farm and construction equipment under 175 horsepower will be included in the proposal to the extent that they can be under section 209(e)(2)[1].

Airport ground support equipment (GSE) would also be subject to the requirements of the proposal. Examples of this equipment include forklifts, tugs, belt loaders, bobtails, cargo loaders, lifts, air conditioner, service trucks, de-icers, fuel delivery trucks, and ground power units. However, GSE in the South Coast Air Basin would be exempt from the requirements of this proposal through 2010. Their emissions are already addressed in a memorandum of understanding between the ARB and the basin's airlines.

Diesel equipment, including diesel forklifts, would not be subject to the requirements of the proposal. 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, ARB is separately controlling emissions from diesel-fueled applications in an expedited timeframe, typically by establishing state-of-the-art technology requirements (like diesel particulate filters). Requirements to control emissions from in-use diesel forklifts will be proposed in late 2005.

D. Emission Reduction Tools and Originally Proposed Concepts

Staff has been working with the LSI technical working group since January 2004 to identify tools for reducing emissions from LSI engines and equipment. Staff evaluated many tools and identified the following as having the most promise to reduce emissions:

[1] The U.S. EPA states that for purposes of sec. 209(e)(2) [where California can ask for a waiver from federal preemption], an engine is no longer new "after a reasonable amount of time has passed."

- 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

Staff combined elements of these tools into three concepts that had the greatest potential to reduce emissions from off-road LSI equipment.

The first concept was a manufacturer lower emission standard. Under this concept, the ARB would first harmonize with the 2007 U.S. EPA standard of 2.0 g/bhp-hr. Then, in 2009, manufacturers would have to certify their equipment to a 1.0 g/bhp-hr standard or a 0.6 g/bhp-hr standard equivalent with the U.S. EPA optional Blue Sky standard.

The second concept was an electric purchase requirement. This concept would have required medium and large fleets meet a 10% electric component in 2007, 20% in 2008, 30% in 2009, and 40% in the years 2010 through 2015.

Under the first two concepts, medium and large fleets would have additionally been required to 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.

The third concept was an owner fleet average. This approach would require LSI fleet owners to meet fleet average emission levels based on engine certification levels and default emission rates for uncontrolled engines. Small fleets of one to three units would be exempt, but must achieve the in-use reductions described earlier.

Staff believes that the fleet average concept provides fleet owners and users the greatest flexibility, with the least burden, because it allows the fleet owner or user to decide the composition of their fleet depending upon operational needs.

Each of these concepts was presented to the public during working group meetings and the May 2004 public workshop. Based on comments received, staff has assembled a new concept that builds upon elements of the first and third concepts.

E. Proposed Requirements

Specifically, staff is proposing a near- to mid-term fleet average requirement that addresses emissions from uncontrolled equipment, as well as causes fleets to move toward low emission or electric equipment. This requirement would be coupled with a manufacturer lower emission standard that ensures very clean LSI equipment in the long term. To assist fleet owners, staff would also establish optional tiered certification levels for new engines and verification levels for retrofits. The following sections

describe the fleet average concept and compliance strategies, the manufacturer lower emission standard and compliance strategies, and the optional tiered certification and verification levels.

1. User Fleet Average Emission Levels

Staff is proposing fleet average emission levels for large and mid-size fleets. Large LSI fleets are those with more than 25 pieces of equipment. The most common example of a large fleet is a distribution facility/warehouse or a large manufacturer. Other companies 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). Mid-size fleets have 4 to 25 pieces of equipment. An agricultural packing warehouse or a mid-size manufacturer is an example of a mid-size fleet.

Large fleets would have to meet more stringent fleet average emission levels than mid-size fleets because they have greater flexibility 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 or Blue Sky 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 use of electric motors is not as prevalent in other equipment 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.

The user 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 average fleet user while maintaining cost effective emission benefits, the fleet average will not incorporate load factor, horsepower, or hours of use.

Small fleets have one to three pieces of equipment. A lumberyard may be an example of a small fleet. Small fleets would be exempt from the fleet average requirement, but would have to achieve an in-use reduction (to 3.0 g/bhp-hr) through retrofit, repower, or rebuild of uncontrolled equipment by the end of 2010. Staff is also considering allowing small fleet users until 2013 to comply with the retrofit requirements if their equipment is used infrequently (in the range of 250 hours per year or less) and has been retrofitted to a lesser level. We welcome your comments on the appropriate usage level and retrofit date.

We also welcome your comments on whether a fleet that expands into the next size category should be provided additional time to comply with the lower fleet average emission level. For regulatory purposes, once a fleet expands and is provided additional time to comply with a fleet average emission level, it must stay in the new size category.

Table 1 lists the proposed fleet average emission levels for FORKLIFT and NON-FORKLIFT LSI fleets.

Table 1:
Fleet Average Emission Level Requirement (g/bhp-hr)

LSI Fleet Type	Number of units	By 2009	By 2011	By 2013
Large fleet – forklift component	26 +	2.3	1.6	0.8
Mid-size fleet – forklift component	4-25	2.5	1.8	1.1
Mid-size or Large Non-forklift fleet	N/A	3.0	2.3	1.7
Small fleet	1-3	N/A	3.0	3.0

a. Fleet Average Compliance Strategies

Fleet users can employ a variety of techniques to achieve prescribed fleet average emission levels. New procurement can be electric or low 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 low emission LSI equipment. Fleet owners may also repower, rebuild or remanufacture old engines or purchase certified used equipment. Details of each of these options follow.

Electric Equipment

The simplest and most effective way to reduce a fleet's average emission level is through procurement of electric equipment, primarily forklifts.

Electric forklifts are most typically used in indoor materials handling applications that do not require large lift capacities (i.e., warehouse/retail operations). There are some applications where electric forklifts are used extensively, primarily for worker safety. These applications 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 electronic compartment to make them more water resistant for outdoor conditions, and alternating current (A.C.) motors that provide greater lift and travel speeds. Class 1 forklifts (electric) 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 on electric forklifts that identify other benefits of electric forklift usage besides improved air quality. One benefit is that electric forklifts 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 is higher for an electric forklift as compared with the LSI forklift, the incremental cost can be recovered during the useful life of the electric forklift. 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 (Class 1); electric motor narrow aisle trucks (Class 2); and electric hand trucks or hand/rider trucks (Class 3). 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 are typically seen performing duties similar to LPG-powered Class 4 and 5 forklifts. Additionally, some Class 2 forklifts have replaced Class 4 forklifts in warehouses that have converted to narrow aisle operations. For the purposes of calculating the fleet average, fleet owners would be able to assign an emission level of zero (0) to Class 1 and Class 2 forklifts. Fleet owners would not be allowed to count Class 3 trucks toward their fleet average, because Class 3 forklifts do not traditionally supplant Class 4 or 5 forklifts.

While some multi-shift operations employ battery swapping and/or fast charging to support the use of a 100 percent electric fleet, staff recognizes that not all users will be able to move toward a 100 percent electric fleet as a result of facility or duty cycle constraints. The next largest emission reduction comes from the procurement of very clean new equipment as described below.

New Equipment Certified to Optional Lower Emission Standards

Staff believes that LSI manufacturers will be able to offer forklifts at emission levels significantly below the current 3.0 g/bhp-hr HC+NOx standard and the 2007 2.0 g/bhp-hr standard using readily available cost-effective emission control technologies like closed-loop fuel control, fuel injection, and three-way catalysts. Greater discussion on the ability of these technologies to reduce emission levels is contained below in section 2.a. Manufacturer New Emission Strategies Compliance Strategies.

Under this proposal, equipment 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. This equipment would provide end users maximum flexibility in meeting the proposed fleet average emission levels in Table 1. It would also allow the ARB to claim credit for actual reductions below the 3.0 and 2.0 g/bhp-hr certification levels.

In-Use Controls

LSI equipment owners would have an array of options that they could select from to meet the required lower emission levels on their in-use engines.

LSI equipment owners may retrofit in-use engines by making modifications or upgrading components on the engine and/or fuel system with ARB verified Retrofit Emission Control Systems (RECS). An example of a RECS, which could be done at the time of scheduled engine maintenance, is a closed-loop fuel control system coupled with a three-way catalytic converter. Some RECS are capable of reducing in-use emissions by more than 80 percent. Under the proposal, RECS would have to reduce emissions by 75 percent or to a 3.0 /bhp-hr HC+NOx level.

LSI equipment owners may repower an existing engine with a new engine that is certified to lower emission standards. By using this strategy the owners would have the option to replace their in-use uncontrolled equipment with an engine that is certified To a 3.0 g/bhp-hr HC + NOx, or lower, emissions standard. Repowers are especially cost-effective if done at the time of a normal engine rebuild.

Another option for LSI equipment owners is to purchase new or used equipment with certified engines.

The vast majority of equipment will be able to achieve significant in-use reductions. However, not all options will be available for all equipment. Some equipment may not have verified RECS. For other equipment, a new-certified engine may not fit in the existing piece of equipment. However the regulation has sufficient flexibility available to fleet users to accommodate any unusual circumstances.

b. Fleet Average Compliance Scenarios

One of the main advantages of a 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 very low-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 equipment. As previously discussed, an uncontrolled forklift has emissions of approximately 12 g/bhp-hr HC + NOx, while current LSI equipment meets a level of 3.0 g/bhp-hr (uncontrolled equipment was available through 2003, although it started being phased out in 2001). The scenarios discussed below assume that by 2009 the fleets have no uncontrolled equipment, i.e., all uncontrolled equipment is retrofitted, repowered or retired. The scenarios also assume an average fleet turnover of seven years. According to ARB's inventory, over 88% of the forklifts within California are seven years old or newer. A shorter fleet turnover rate (more modern fleet) 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, a 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, a large fleet would be required to meet a standard of 2.3 g/bhp-hr and a mid-sized fleet would be required to meet a standard of 2.5 g/bhp-hr.

One straightforward way to meet the fleet average requirement is to utilize a modest percentage of electric equipment. Specifically, large fleets could meet the first fleet average requirement by incorporating 15 percent electric equipment, while a mid-size fleet would only need 8 percent electric. A fleet that chooses not to incorporate <u>any</u> electric equipment would need to be more aggressive. A large fleet could meet the requirements by shifting from a fleet with a seven-year to a six-year life and purchasing optional low-emission forklifts at 1.0 g/bhp-hr in 2007 and 2008. A mid-size fleet could meet their requirements while maintaining their seven-year fleet life through the purchase of the same 1.0 g/bhp-hr forklifts in 2007 and 2008.

The 2011 requirements continue requiring fleets to pursue zero or low-emission equipment. Staff expects significantly more equipment to be available that meets the optional low-emission standards. A large fleet could meet the proposed requirement of 1.6 g/bhp-hr by utilizing approximately 28 percent electric. Without any electric equipment, a large fleet could meet the 2011 requirement by maintaining its six-year life and purchasing forklifts meeting a 0.6 g/bhp-hr standard, which is the proposed standard for all LSI beginning in 2010.

A mid-size fleet could meet the 1.8 g/bhp-hr requirement in 2011 through the use of approximately 20 percent electric or the continued purchase of low-emission forklifts meeting a 1.0 g/bhp-hr standard in 2009 and 0.6 g/bhp-hr in 2010.

The 2013 requirements are achievable through continued steady turnover of the fleet with new forklifts meeting the proposed mandatory standard for LSI of 0.6 g/bhp-hr, starting in 2010.

The fleet standards for non-forklifts are set to be conservative. 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 low-emission standards in this category will make compliance with the proposed standards easier.

c. Diesel Equipment

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. The ARB is beginning a regulatory effort to address emissions from off-road in-use diesel equipment. It will focus on reducing toxic particulate matter emissions from the diesel forklift through required retrofits in an expedited time frame. Thus, this proposal does not address emission standards for diesel equipment, including forklifts

d. Fleet User Record-keeping Requirements

For enforcement purposes, the fleet average emission level proposal would require fleet users to maintain the following fleet average information: equipment type, make, model, serial number, and emission certification level or retrofit verification level at their facility. Users would be required to maintain that information on file for three years or until inspection, whichever is longer. For the purposes of this proposal, rental companies would be considered fleet users for any equipment rented for periods of 30 days or less.

2. Manufacturer Lower Emission Standard

The proposed manufacturer lower emission standard would require LSI engine manufacturers to certify their 2010 and subsequent model year engines to an emission standard of 0.6 g/bhp-hr HC +NOx. This is more stringent than the 2007 U.S. EPA 2.0 g/bhp-hr standard, but is consistent with their optional Blue Sky standard, and reflects observed and expected advancements in emission control technology, as discussed below.

As outlined in earlier sections, staff is pursuing a user 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 emission levels become lower, they become closer together 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 ultimate emission level and to benefit by bringing that product to market under the optional low-emission standards.

The technology, as discussed below, is clearly available from the automotive sector to reach these levels and is cost-effective. Therefore, the timing of the proposal was developed to provide manufacturers sufficient time to design the technology into this application in such a way that does not place an undo burden on the industry given the pending implementation of the 2007 standards and requirements.

Staff would appreciate comments on the several ideas related to a manufacturer emission standard: First, technology from the automotive sector would imply that even lower emission standards in the range of 0.2 g/bhp-hr are feasible. This level, however, is probably not reasonable in 2010. Staff is considering delaying the implementation of the manufacturer standard until 2013 and implementing the lower 0.2 g/bhp-hr requirement. Second, staff is considering an averaging, banking, and trading component as part of this proposal in order to provide additional flexibility to manufacturers. Staff would especially welcome comments on how to allow the banking component without double-counting the emissions benefits with optional low-emission forklifts purchased by fleets to meet their fleet average requirements. Finally, staff is considering an exemption for very low sales volumes and would appreciate comments on an appropriate volume.

a. Manufacturer New Emission Standard Compliance Strategies

Off-road LSI engines are similar to automotive engines, but have traditionally lacked automotive-style emission controls that have been in use for more than 20 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 beginning to apply automotive-style emission reduction technologies to the off-road LSI engine sector to reduce exhaust emissions. Typically these technologies include closed loop fuel controls, fuel injection, and three-way catalytic converters.

Automotive emission control systems use a closed-loop fuel control system and a fuel injection system to ensure precise metering of fuel and optimum combustion. They use feedback from an oxygen sensor to maintain a stoichiometric air-fuel mixture. This optimizes catalytic efficiency of HC, CO, and NOx, as well as catalyst durability.

Automotive emission control systems also use a proven method of controlling exhaust emissions – the three-way catalytic converter. Automotive manufacturers have installed tens of millions of them each year for more than 20 years. They are an integral component of automotive emission control systems that have allowed our automotive fleet to meet progressively lower emission standards – effectively reducing concentrations of carbon monoxide, hydrocarbons and oxides of nitrogen by more than

90 percent. Emission control catalysts make use of the platinum group metals – platinum, palladium and rhodium.

Staff expects that 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. But staff believes there is plenty of room for improvement. After all, an engine certified to the 2.0 g/bhp-hr standard will still emit as much as ten or more of the least expensive new cars available. This reflects the slow adoption of newer emission control technologies into LSI equipment. The advanced three-way catalysts are components of LSI retrofit kits and new engines and have been demonstrated to be robust, but are still based on twenty-year old technology.

Manufacturers can make their equipment more efficient still. In general, the catalysts used in LSI equipment are significantly smaller, utilize less sophisticated catalyst washcoats, have lower cell densities, and use fewer precious metals than automotive catalysts. 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.

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. Since NOx constitutes approximately 80 percent of the HC + NOx emissions, the new test cycle could lead to a potential emissions increase of only 6 percent over those under the steady state test cycle. 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.

b. Manufacturer Optional Tiered New Emission Standards

As discussed above, staff is proposing optional tiered new emission standards. These standards will provide fleet owners with additional flexibility in meeting the proposed fleet average emission level requirements. 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.

F. Air Quality and Economic Impacts

1. Air Quality Impacts

Table 2 lists the 2010 estimated emission benefits of the proposed regulation. This was based on staff's preliminary analysis of available information, including industry market data, industry's input, and emission inventory outputs from the ARB's OFFROAD model. The emission benefit estimates shown in Table 2 reflect the staff's initial proposal that

was presented at the May 26, 2004, workshop. The staff's initial fleet average emission level has been revised, including requirements for new engine emission standards that will have additional and significant emission benefits beyond 2010. Staff will perform a more in-depth analysis of the emission impacts of the proposed regulation to include the long-term 2015 and/or 2020 benefits and will include the revised emission benefits in subsequent regulatory documents. The emission benefits listed in Table 2 are estimated for all off-road LSI equipment of 25 horsepower and greater. Table 3 shows the estimated emission benefit in 2010 of the staff's proposal for the South Coast Air Basin, relative to the SIP emission reduction commitment for that region.

Table 2:
Preliminary 2010 Estimated Statewide Emission Benefit of Staff Proposal
HC+NOx (tons per day)

Staff Proposal	Emission Reductions[1]
Fleet Average Emission Requirements [2]	11.2
Retrofit Requirements [3]	1.2
Total	12.4

Notes: [1] Assumes 100 percent compliance
[2] These requirements apply to fleets with 4 or more pieces of off-road LSI equipment
[3] These requirements apply to fleets with fewer than 4 pieces of off-road LSI equipment

Table 3:
Preliminary Emission Benefits from Staff Proposal Compared to
The 2003 SIP Target for the South Coast Air Basin in 2010
HC+NOx (tons per day)

Measure	Emission Reductions
2003 SIP OFF-RD LSI-2 Consolidated	6.0
Staff's Proposal	6.2[1]

Notes: [1] Assumes SCAB LSI equipment population is one-half of statewide LSI equipment population

2. Economic Impacts – Cost and Cost-Effectiveness

Since the staff proposal contains different requirements applicable to fleets of different sizes, staff evaluated the economic impacts to comply with each requirement. The total economic impact of the staff proposal is determined by summing up the economic impacts of the various components of the staff proposal.

Under the staff proposal, fleets of 26 or more off-road LSI engines have to achieve a fleet average emission level of 2.3 g/bhp-hr HC+NOx by 2009 for all forklifts in their fleets. Fleets with 4 to 25 pieces of off-road LSI equipment have to achieve a fleet average emission level of 2.5 g/bhp-hr HC+NOx by 2009 for all forklifts in their fleets. In addition, large and mid-size fleets also have to comply with a fleet average emission level of 3.0 g/bhp-hr for all other non-forklift LSI equipment in their fleets. These fleets would have the flexibility to decide the mix of options to achieve the required fleet average emission levels. Among the possible options are retrofit, early purchase new equipment that is certified to lower emission standards, or optional emissions standards, and purchase of electric equipment instead of combustion-powered equipment.

Fleets that have three or fewer pieces of off-road LSI equipment are required to reduce the HC+NOx emissions from all of their uncontrolled off-road LSI engines to Step 2 by 2010. These fleets would have an array of technology options to achieve the Step 2 requirement; from retrofit, to equipment repower, to purchase of used emission-controlled equipment. Staff assumes that, on average, fleets would employ a combination of these technology options to comply with the staff proposal.

Staff evaluated several possible scenarios that these fleets could use to meet their required fleet average emission levels. The costs associated with these control technology options range from a low of about $900 for a retrofit to as high as about $4,000 for the incremental cost of an electric forklift compared to an equivalent internal combustion forklift, in 2010 dollars. The total life-cycle cost of an electric forklift, however, is lower than the life-cycle cost of an equivalent internal combustion engine forklift, when factors such as reduced operating and maintenance costs are accounted for. Staff estimates that the statewide cost-effectiveness of the proposal would range from about $2,400 per ton to about $10,000 per ton of HC+NOx emissions reduced. The actual cost-effectiveness to comply with the staff proposal would vary for each fleet, depending on the specific requirements for that fleet, and the strategy the fleet chooses to comply with those requirements. The above cost-effectiveness analysis did not take into account possible cost savings associated with reduced operating and maintenance costs that could be expected from the use of more advanced technology.

G. Issues

Two additional issues raised by work group participants are discussed below. Staff is soliciting comments on the impact of these issues in the proposed regulations.

1. Fuel Quality

Liquefied petroleum gas (LPG) is a mixture of various hydrocarbons harvested from the refining extract from crude oil or the processing extract from natural gas. Propane is the predominant component of LPG. Clean LPG fuel is necessary to reach very low emissions levels; a dirty fuel can prevent an engine from complying with future emissions standards. There are two separate concerns about LPG fuel quality. Contaminated fuel can have an immediate and sometimes catastrophic impact on the fuel delivery system and the emissions control system. Additionally, normal

constituents in the fuel can accumulate, adversely affecting these systems in the long term. This accumulation is often the result of using commercial grade fuel, intended primarily as a heating fuel, in motor vehicles. Commercial grade fuel has a higher olefin content than motor vehicle grade LPG. These olefins oxidize, creating 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 improper aspiration of fuel.

The ARB has established LPG motor vehicle fuel specifications, and 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.

2. Fleet Average for Sweepers

Staff is considering adding sweepers to the more stringent “forklift component” fleet average since electric sweepers are available.