Control Measure to Reduce Emissions from Forklifts and Other Industrial Equipment

May 25-26, 2006: Sacramento, California
What are “Large Spark-Ignition Engines”?

- Gasoline and LPG
- Older automotive technology
- Greater than 25 hp and 1 liter
- Typical life of 7-11 years
Examples of LSI Equipment

- Forklifts
Examples of LSI Equipment

- Forklifts
- Airport ground support
Examples of LSI Equipment

- Forklifts
- Airport ground support
- Sweepers/scrubbers
Examples of LSI Equipment

• Forklifts
• Airport ground support
• Sweepers/scrubbers
• Industrial tow tractors
Examples of LSI Equipment

• Forklifts
• Airport ground support
• Sweepers/scrubbers
• Industrial tow tractors
• Generator sets
Examples of LSI Equipment

- Forklifts
- Airport ground support
- Sweepers/scrubbers
- Industrial tow tractors
- Generator sets
- Turf care equipment
Examples of LSI Equipment

- Forklifts
- Airport ground support
- Sweepers/scrubbers
- Industrial tow tractors
- Generator sets
- Turf care equipment
- Other non-preempted industrial, construction, and agricultural equipment
LSI Emissions

- 88,000 LSI engines
  - 40,000 forklifts
- HC+NOx emissions:
  - 70 tons per day in 2004
  - about 5 percent of off-road mobile source emissions
History of Control

- **1998**: ARB Adopts First LSI Rule
- **2001**: Implementation of ARB Standards Begins
- **2002**: U.S. EPA Finalizes Standards
- **2004**: ARB Requires 100% Compliance/EPA’s Standards Implemented
- **2007**: EPA Standards Become More Stringent
Comparative Emissions

**HC+NOx (g/bhp-hr)**

<table>
<thead>
<tr>
<th>Year</th>
<th>LSI</th>
<th>Diesel Trucks</th>
<th>Cars*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>3.0</td>
<td>2.5</td>
<td>0.1</td>
</tr>
<tr>
<td>2007</td>
<td>2.0</td>
<td>1.5</td>
<td>0.1</td>
</tr>
<tr>
<td>2010</td>
<td>2.0</td>
<td>1.5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

*Approximate
2003 State Implementation Plan Commitment

- SIP Measure LSI-1
  - harmonize with 2007 EPA new engine standards
- SIP Measure LSI-2C
  - Existing engines - reduce emissions by 80%
  - Incorporate zero- and near-zero-emission technologies
- Reduce statewide HC+NOx emissions
  - 6 to 13 tons per day by 2010
Elements of the Proposal

- New Engine Standards
- In-Use Fleet Average
- New Engine Test Procedures
- Retrofit Verification Procedures

LSI Rulemaking
Elements of the Proposal

New Engine Standards

In-Use Fleet Average

New Engine Test Procedures

Retrofit Verification Procedures

LSI Rulemaking
Proposed New Engine Standards

- 2.0 g/bhp-hr HC+NOx in 2007
  - Aligns with EPA
- 0.6 g /bhp-hr HC+NOx in 2010
  - Draw upon automotive emission control technology

HC + NOx Standards

- 2004: 3.0 g/bhp-hr
- 2007: 2.0 g/bhp-hr
- 2010: 0.6 g/bhp-hr
# Technology Comparison

<table>
<thead>
<tr>
<th></th>
<th>2004 Forklift</th>
<th>2010 Forklift*</th>
<th>Typical 2004 Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel System</td>
<td>Carb/TBI</td>
<td>TBI/SMPI</td>
<td>SMPI</td>
</tr>
<tr>
<td>Catalyst Volume (% of engine)</td>
<td>40%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Grams of Pt</td>
<td>0.77</td>
<td>&gt; 2</td>
<td>&gt; 2</td>
</tr>
<tr>
<td>Grams of Rh</td>
<td>0.19</td>
<td>&gt; 0.4</td>
<td>~ 2</td>
</tr>
<tr>
<td>Cert. Emissions (HC+NOx g/bhp-hr)</td>
<td>1</td>
<td>0.1 – 0.3</td>
<td>0.06**</td>
</tr>
<tr>
<td>Emission Std. (HC+NOx g/bhp-hr)</td>
<td>3.0</td>
<td>0.6</td>
<td>0.15**</td>
</tr>
</tbody>
</table>

*Based on cleanest model available today

**Approximate
Optional Manufacturer Lower Emission Standard

• Optional Tiered Certification
  – Model year 2007 and later
  – Early use of available clean technologies
  – Certify to 1.5, 1.0, 0.6, 0.4, 0.2 and 0.1 g/bhp-hr
  – Credits
Elements of the Proposal

- New Engine Standards
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- New Engine Test Procedures
- Retrofit Verification Procedures

LSI Rulemaking
New Engine Test Procedures
Beginning in 2007

• New EPA test procedures in 2007
• Proposal aligns with federal test procedures and compliance provisions:
  – Transient test procedure in 2007
  – Near complete alignment from 2007 - 2009
  – Typical differences in 2010 and beyond
  – Keep more stringent or protective ARB language
    • In-use compliance and auditing
    • Warranty and labeling
Elements of the Proposal

- New Engine Standards
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LSI Rulemaking
In-Use Fleet Average Concept

• Uncontrolled Equipment = High Emissions
  – All pre-2001 and about half of 2001-2003 engines
  – An uncontrolled forklift operating three shifts = cleanest certified car over its entire life

• Retrofit, replace, or retire
  – Ensures turnover
  – Control or replacement of uncontrolled engines
In-Use Fleet Average Proposal

• Establishes declining fleet average levels
  – Retrofit or replace uncontrolled equipment by 2009
  – Replace some LSI with zero or near-zero emission equipment

• Applies to
  – operators of forklifts, sweepers/scrubbers, tow tractors, and airport ground support equipment
  – owned equipment; rental/lease greater than one year
## In-Use Fleet Average Standards

*(Fleet Average Emission Level in Grams HC+NOx)*

<table>
<thead>
<tr>
<th>LSI Fleet Type</th>
<th>Number of units</th>
<th>By 1/1/2009</th>
<th>By 1/1/2011</th>
<th>By 1/1/2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large fleet – forklift component</td>
<td>26 +</td>
<td>2.4</td>
<td>1.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Mid-size fleet – forklift component</td>
<td>4-25</td>
<td>2.6</td>
<td>2.0</td>
<td>1.4</td>
</tr>
<tr>
<td>Non-forklift fleet</td>
<td>N/A</td>
<td>3.0</td>
<td>2.7</td>
<td>2.5</td>
</tr>
</tbody>
</table>
In-Use Fleet Average Compliance Strategy

- **Clean up uncontrolled equipment**
  - Retrofit control technology exists
    - Available since mid-1990’s
  - Two systems verified
    - ~ 90 percent emission reduction
  - Applicable to most 1990 and newer LSI engines
  - ~ $3,500 installed
  - Improved fuel economy

- **Purchase lower-emission equipment**
  - New or used equipment certified to optional lower-emission standards
In-Use Fleet Average Compliance Strategy

• Electric
  – Commercially available
  – Increasingly capable
  – $2,000 – $5,000 more than a comparable LSI lift
  – Lower life cycle costs

• Fuel Cell
  – Commercialization has begun
  – Eliminates battery issues
In-Use Fleet Average Modifications

• June 2005 Board feedback
  – Reduce economic impact on dealers and agricultural businesses
  – Find funds to reduce compliance cost
  – No external funding secured

• Staff works with stakeholders to modify proposal

• Modifications identified
  – Significantly lower compliance cost
  – Some loss of emission benefit
  – Consistent with Board direction
Modifications to Staff Proposal
(made since June 2005)

- Forklift dealers
- Agricultural operations
- Airport ground support equipment (GSE)
- Engines less than 1 Liter
Dealers - Revised Proposal

• Original Proposal
  – Dealers could be responsible for clean-up of vehicles coming off current leases
  – Costs high – not planned - not recoverable

• Revised proposal
  – Exempt small fleets from reg. (1-3 units)
  – Provides dealers with a sales outlet for used equipment coming off lease
  – Reduces costs to dealers
  – 1 ton/day less emission reduction (2010)
Agricultural Operations – Revised Proposal

• Original Proposal
  – Reduce emissions of 10% of fleet per year
  – 3 g/bhp-hr level
  – Many old forklifts – only option is replacement at higher cost

• Revised Proposal
  – Only 1990+ forklifts that can use a retrofit kit subject to rule
  – Delayed implementation
  – Cost reduced by 90-98%
  – 0.4 ton/day less emission reduction
Airport GSE Equipment
Revised Proposal

• Original Proposal
  – Airlines in LA must have 30% of fleet zero emission (e.g. electric baggage carts)
  – Proposed regulation replaces MOU terminated by airlines in 2005

• Revised Proposal
  – Eliminate zero emission requirement
  – Airline recently demonstrated they already comply
Engines Less Than 1 Liter
Revised Proposal

- Original Proposal
  - Not subject to proposed new standards or fleet requirements
  - Allow optional compliance with lawn and garden standards and procedures
  - Simpler test

- Revised Proposal
  - Defer until determined if further emission reductions possible
  - Return to Board with proposal
Elements of the Proposal

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LSI Rulemaking
Retrofit Verification

- Verify emission reductions
  - Percentage reduction
  - Absolute emission level
    - Ranges from 0.5 to 3.0 g/bhp-hr
- Field demonstration
- In-use compliance testing
- Installation and performance warranty
  - 3 years or 2,500 hours
- Labeling requirement
- Two retrofit kits verified
Estimated Benefits and Cost Effectiveness of the Proposal
### Emission Benefits

**Emission Reductions (HC+NOx)**

<table>
<thead>
<tr>
<th>Benefit (tpd)</th>
<th>2010</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Proposal</td>
<td>7.2</td>
<td>6.6</td>
</tr>
<tr>
<td>New Proposal</td>
<td>5.6</td>
<td>6.2</td>
</tr>
<tr>
<td>SIP Commitment</td>
<td>6.1–13.0</td>
<td>3.3 to 11.1</td>
</tr>
</tbody>
</table>
## Cost-Effectiveness

<table>
<thead>
<tr>
<th>Proposal Element</th>
<th>Dollars per Pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Engine Standards</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>In-Use Requirements:</strong></td>
<td></td>
</tr>
<tr>
<td>Retrofit</td>
<td>0 – 1.00</td>
</tr>
<tr>
<td>Zero-Emission</td>
<td>0 – 1.40¹</td>
</tr>
</tbody>
</table>

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

• 2010 standards for new engines
• Fuel quality
Issue – 2010 New Engine Standards

• Issue: Feasibility of the 2010 standards
  – Stringency
  – Lead time

• ARB staff response:
  – 2010 standards achievable:
    • Better emission controls available
    • One engine tested at 0.7 g/bhp-hr
    • Cars currently emit at ¼ the 2010 standard
Issue – Fuel Quality

• Issue: Manufacturer concern with LPG fuel quality
  – Impact of poor fuel quality on engine performance

• ARB staff response: Continue to evaluate
  – Data collection
  – Contract in process
  – Report to Board as necessary
Conclusions

• Significant emission reductions
• Proposed modifications:
  – Reduce costs
  – Result in some loss in emission benefit
• Standards are attainable with existing technologies
• Staff recommends Board adoption with proposed modifications