# Presentation to U.S. EPA Technical Advisory Committee Regarding California Phase 3 Reformulated Gasoline Program

**January 12, 2000**

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**California’s Gasoline Programs**

<table>
<thead>
<tr>
<th>Year Adopted</th>
<th>Major Changes Made</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>Reid Vapor Pressure</td>
</tr>
<tr>
<td>1975</td>
<td>Sulfur</td>
</tr>
<tr>
<td>1976</td>
<td>Lead</td>
</tr>
<tr>
<td>1990</td>
<td>Phase 1 RFG</td>
</tr>
<tr>
<td></td>
<td>- Reid Vapor Pressure</td>
</tr>
<tr>
<td></td>
<td>- Lead Phase-Out</td>
</tr>
<tr>
<td></td>
<td>- Deposit Control Additives</td>
</tr>
<tr>
<td>1991</td>
<td>Phase 2 RFG</td>
</tr>
<tr>
<td></td>
<td>- 8 properties, including RVP</td>
</tr>
<tr>
<td></td>
<td>Wintertime Oxygenates</td>
</tr>
<tr>
<td>1994</td>
<td>Phase 2 RFG Predictive Model</td>
</tr>
<tr>
<td>1998</td>
<td>Remove winter oxygen requirement where not needed</td>
</tr>
</tbody>
</table>
Overview of CaRFG2 Program

- Implemented in Spring 1996
- Limits on the following parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Flat Limit Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVP*</td>
<td>7.0 psi</td>
</tr>
<tr>
<td>Sulfur</td>
<td>150 ppmw</td>
</tr>
<tr>
<td>T50</td>
<td>7.0</td>
</tr>
<tr>
<td>Benzene</td>
<td>40</td>
</tr>
<tr>
<td>T90</td>
<td>2.0</td>
</tr>
<tr>
<td>Aromatic Hydrocarbons</td>
<td>25</td>
</tr>
<tr>
<td>Olefins</td>
<td>9.9</td>
</tr>
<tr>
<td>Oxygen Content</td>
<td>0</td>
</tr>
<tr>
<td>T90, deg F</td>
<td>330</td>
</tr>
<tr>
<td>T50, deg F</td>
<td>220</td>
</tr>
</tbody>
</table>

* Only the summer RVP limit is fixed, at 7.0 psi

Specifications for CaRFG2 Program

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical Before CaRFG2</th>
<th>Flat Limit Standard</th>
<th>Cap for All Gasoline</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVP, psi</td>
<td>7.8</td>
<td>7.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Sulfur, ppmw</td>
<td>150</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>Aromatic HC, vol%</td>
<td>32</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Benzene, vol%</td>
<td>2.0</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Olefins, vol%</td>
<td>9.9</td>
<td>6.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Oxygen, wt%</td>
<td>0</td>
<td>1.8-2.2</td>
<td>1.8*-3.5</td>
</tr>
<tr>
<td>T90, deg F</td>
<td>330</td>
<td>300</td>
<td>330</td>
</tr>
<tr>
<td>T50, deg F</td>
<td>220</td>
<td>210</td>
<td>220</td>
</tr>
</tbody>
</table>

* Wintertime only
** Refinery cap = 310 deg F
Benefits of Cleaner-Burning Gasoline

✦ Emission reductions equivalent to removing 3.5 million vehicles from region’s roads
✦ Reduces smog forming emissions from motor vehicles by 15%
✦ Reduces potential cancer risk from vehicle emissions by 40%
✦ 1/4 of SIP reductions in 1996
✦ Reduces benzene emissions by half

Additional Emission Benefits
1998 In-Use Fuel Compared to CaRFG2 Specifications
2005 (tpd)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Additional Benefits Realized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Hydrocarbons (HC)</td>
<td>31 tpd</td>
</tr>
<tr>
<td>Oxides of Nitrogen (NOx)</td>
<td>32 tpd</td>
</tr>
<tr>
<td>Toxics</td>
<td>12%</td>
</tr>
</tbody>
</table>

* Based on on-road exhaust and evaporative emissions
Cost of CaRFG2

- ARB staff originally estimated CaRFG2 would add 5 to 15 cents per gallon to gasoline production costs
- In 1996, California Energy Commission estimated CaRFG2 accounted for 5-8 cents per gallon increase in price of California gasoline
- November 1999, State Attorney General assessment
  - Wholesale prices for CARB gasoline has averaged about 4 cents greater than conventional gasoline

History of Oxygenate Use

- Used since late 1970’s to increase octane
- Clean Air Act required oxygen in winter gasoline starting in 1992 in CO non-attainment areas
- Year-round in federal RFG areas starting in 1995 (30% of gasoline nationwide)
- MTBE refiner’s primary choice
Oxygen Requirements in California

✦ California’s rules are flexible
✦ Emissions benefits can be met without oxygen except in winter in the South Coast area to reduce carbon monoxide
✦ Federal minimum oxygen content applies to Federal RFG areas and is a year-round requirement

Federal Minimum Oxygen Requirement Affects Most of State

Federal RFG area in 2000 (~10% of gasoline)

Current Federal RFG areas affect about 70% of gasoline sold

Federal RFG Areas
1991 - San Diego
   South Coast Region
   Ventura
1995 - Sacramento Region
2000 - San Joaquin Valley
Governor’s Findings

Based on study by University of California, and public hearings Governor found:

✦ MTBE presents threat to groundwater, surface water, and drinking water
  – Underground gasoline storage tanks are not leak proof
  – MTBE is highly soluble in water and transfers to groundwater faster than other constituents in gasoline
  – MTBE in small amounts renders drinking water unusable
✦ MTBE potential but not proven health problem
✦ MTBE not essential to cleaner-burning gasoline

Governor’s Executive Order

✦ On March 25, 1999 Governor Davis issued Executive Order D-5-99 for the phase-out of MTBE from California gasoline by earliest practical date but not later than December 31, 2002
✦ Directs ARB to adopt CaRFG regulations to provide additional flexibility in removing oxygen while preserving benefits
✦ Directs ARB to request waiver from Federal Oxygen Requirement from U.S. EPA
Other Key Directives from Executive Order D-5-99

- ARB and the SWRCB to conduct analysis of environmental fate and transport of ethanol
- OEHHA to prepare an analysis of the health risks associated with the use of ethanol
- CEC to evaluate steps to foster waste-based or other biomass ethanol development in California if ethanol acceptable substitute for MTBE

New State Legislation

- Senate Bill 989 (Sher)
  - Ensure the CaRFG3 regulations maintain or improve upon emissions and air quality benefits achieved by CaRFG2 and provide additional flexibility to reduce or remove oxygen from motor vehicle fuel
- Senate Bill 529 (Bowen)
  - Establishes a mechanism for conducting multi-media review of revisions to ARB’s CaRFG standards
- Governor’s Environmental Policy Council review January 18, 2000
External Process

✦ Phase 3 gasoline (CaRFG3)
  – Met with individual stakeholders
  – Held 9 public workshops
  – Work with California Energy Commission
✦ Advised by consultants from the University of California
  – Dr. Robert Sawyer, UC Berkeley
  – Dr. David Rocke, UC Davis
✦ Peer Review
  – Dr. Catherine Koshland, UC Berkeley
  – Dr. Donald Lucas, UC Berkeley and Lawrence Berkeley National Laboratory
  – Dr. Larry Caretto, CSU Northridge, Dean of College of Engineering

Overview of CaRFG3 Regulations

✦ Prohibit use of MTBE
✦ Change specifications to ensure benefits are preserved and to provide flexibility
✦ Update Predictive Model
✦ Evaporative emissions model added to Predictive Model
✦ Provide CO credit
✦ Increase oxygen cap for 10 percent ethanol blends
✦ Amend wintertime oxygenate period
✦ Amend the provisions (CaRBOB) for ethanol blending
✦ Wintertime Oxygen Program
✦ Early Opt-In
Prohibition on Adding MTBE to Gasoline

✦ Consistent with Governor’s Executive Order, effective December 31, 2002, MTBE cannot be added to gasoline
✦ Deminimus residual levels to be phased in over a three year period

Proposed Specification Changes

✦ Reduce limits for sulfur and benzene to ensure benefits are preserved
✦ Increase limits for T50 and T90 and increase cap limit for aromatic hydrocarbons to provide flexibility
✦ Allow RVP to vary (6.4 to 7.2 psi.) with use of proposed evaporative model to provide flexibility
### Specifications for CaRFG3

<table>
<thead>
<tr>
<th>Property</th>
<th>Flat Limits</th>
<th>Averaging Limits</th>
<th>Cap Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVP, psi</td>
<td>7.0&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>none</td>
<td>6.4-7.2</td>
</tr>
<tr>
<td>Benzene, vol%</td>
<td>0.80</td>
<td>0.70</td>
<td>1.10</td>
</tr>
<tr>
<td>Sulfur, ppmw</td>
<td>20</td>
<td>15</td>
<td>60/30&lt;sup&gt;(3)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Aromatic HC, vol%</td>
<td>25</td>
<td>22</td>
<td>35</td>
</tr>
<tr>
<td>Olefins, vol. %</td>
<td>6.0</td>
<td>4.0</td>
<td>10</td>
</tr>
<tr>
<td>Oxygen, wt. %</td>
<td>1.8 to 2.2</td>
<td>na&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>3.7&lt;sup&gt;(4)&lt;/sup&gt;</td>
</tr>
<tr>
<td>T50 °F</td>
<td>213</td>
<td>203</td>
<td>220</td>
</tr>
<tr>
<td>T90 °F</td>
<td>305</td>
<td>295</td>
<td>330</td>
</tr>
</tbody>
</table>

1) Equal to 6.9 psi if using the evaporative element of the Predictive Model
2) Not Applicable
3) 60 ppmw will apply December 31, 2002; 30 ppmw will apply December 31, 2004
4) Allow 3.7 for gasoline containing no more than 10 volume percent ethanol

### Updates to the Predictive Model

- More powerful statistics used
- Additional emissions data from nine studies included
  - About 2,500 additional data points
- New technology group added to model to reflect newer vehicles
  - 1996 to 2005 model year vehicles (“Tech 5”)
- Update weights for vehicle technology groups to reflect 2005 vehicle fleet
Evaporative Emissions Element
Added to the Predictive Model

✦ Allows exhaust hydrocarbons and evaporative hydrocarbons trading
✦ Increases flexibility
✦ Credit for RVP reductions

Added CO Credit

✦ Provides credit recognizing role of CO in ozone formation
Changes to the CARBOB Provisions

✦ Limited changes to simplify distribution with use of ethanol
✦ Further changes needed
✦ The staff is committed to address other necessary changes next year

Wintertime Oxygen Requirement for South Coast

✦ Remove the month of October from the wintertime oxygen season in the South Coast Air Basin starting in 2003
  – Continues to be effective November through February
  – Only 1 exceedance during October in last 4 years
✦ By 2003 no exceedances of the CO standard would be expected in the month of October.
Early Access to CaRFG3

- Facilitate early MTBE removal
- Ensure continued enforceability of regulations

Overview of Effects

- Emissions
- Economics
- Production volume
- Environmental effects
Effect on Emissions

✦ Air Quality Objectives
   – Preserve emission benefits
   – Meets SB 989 (Sher) and Governor’s Executive Order requirements

Preserving Benefits

✦ Determined average properties of gasoline marketed in 1998
✦ Determined emissions benefits achieved with 1998 in-use gasoline
✦ Proposed specifications so that future in-use gasoline would be required to be as clean as 1998 gasoline
✦ Verified proposed specifications more stringent than CaRFG2 specifications
**Benefits of In-Use CaRFG2 Preserved**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Emissions (2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
</tr>
<tr>
<td>Hydrocarbon</td>
<td>- 0.1%</td>
</tr>
<tr>
<td>Oxides of Nitrogen (NOx)</td>
<td>- 1.2%</td>
</tr>
<tr>
<td>Potency Weighted Toxics</td>
<td>- 1.8%</td>
</tr>
</tbody>
</table>

na - not applicable

**Estimated Production Cost for CaRFG3**

- Estimated capital costs significantly less than $1 billion, mostly for MTBE removal
- In October, estimates of ongoing costs were 2 to 6 cents per gallon
- Ethanol industry and at least one refiner believe actual costs will be less
- Federal oxygen waiver could reduce costs up to 2 cents per gallon
- Under right conditions costs could be zero
  - If cost of ethanol or alkylate blendstocks are less than MTBE
Environmental Impacts of CaRFG3

- MTBE contamination of existing water sources will be limited to pre-existing MTBE contamination
- Less benzene contamination of surface and ground water
- Increased ethanol use may result in slight increase in transportation emissions from rail and heavy duty trucks
- No net increase in greenhouse gas emissions
- Decreases in NOx, potency weighted toxics and equivalency on hydrocarbon emissions

Effects on Air and Water Quality

- ARB and SWRCB are evaluating the environmental fate and transport of ethanol in air and water
- OEHHA evaluating health impacts
- To be considered by the Environmental Policy Council (January 18, 2000)
Effects of Commingling Gasoline with Ethanol and Gasoline Without Ethanol

✦ When gasoline with ethanol is blended with gasoline without ethanol, RVP increases
  – Results in higher evaporative emissions
✦ Effect on emissions depends on various factors
  – Oxygen waiver
  – Refiner choices; mix of fuel available in given area
  – Consumer choices; brand loyalty and grade loyalty

Commingling Impacts

✦ The staff estimates commingling could increase average RVP by about 0.1 psi
✦ Proposed specifications provide cushion for commingling effects
✦ Propose commingling study by December 2001 to assure we have addressed commingling
Next Steps

✦ Follow up on EPA oxygen waiver
✦ Adjust predictive model to reflect final EMFAC 2000
  – RVP and evaporative emissions relationship
  – Vehicle group weightings
✦ Return to Board by October 2000
  – CARBOB Amendments
  – Finalize small refiner provisions
  – Denatured ethanol specification
✦ Request US EPA to consider national DI specification
✦ Environmental Policy Council review January 18, 2000
✦ Initiate process to monitor refiner progress toward compliance

Next Steps (Continued)

✦ Conduct commingling study in 2001
✦ In 2004
  – Evaluate real-world CaRFG3 gasoline properties to ensure real-world benefits of CaRFG2 are preserved
  – Evaluate real-world DI levels in CaRFG3
  – Complete evaluation with CEC on impacts of near zero sulfur levels in gasoline (including impacts on supply and cost of production), and CaRFG3 in-use sulfur levels
Conclusion

✦ The Board adopted the staff proposal to phase out MTBE and to provide refiners additional production flexibility while maintaining the emissions benefits of the existing reformulated gasoline program
✦ The Board directed staff to return no later than October 2000 to address CaRBOB, denatured ethanol specifications, and small refiner provisions

Predictive Model

✦ Used for virtually all gasoline produced
✦ Predicts how exhaust emissions change when fuel properties change from flat specifications
✦ Provides alternative means of compliance
✦ Increases gasoline producer’s flexibility
✦ Reduces compliance costs / improves production capability
Independent Peer Review of Staff’s Assessment

✧ Followed Cal/EPA formal process for conducting peer review
  – Staff Proposal
  – Predictive Model
✧ Peer reviews confirm staff proposal meets objectives