State of California

MEMORANDUM

To : Jack Lagarias
Board Member

Date : August 18, 1992

Subject : Evaluation of Chevron's Paper Published in the Environmental Science and Technology Journal

Through: James D. Boyd
Executive Officer

Peter D. Venturini, Chief
Stationary Source Division
From : Air Resources Board

This paper presents the results of a test program conducted by Chevron Research designed to investigate the effects of gasoline reformulation on exhaust emissions and on the ozone forming potential of the exhaust emissions. The results were published in the Environmental Science and Technology Journal titled "Speciated Measurements and Calculated Reactivities of Vehicle Exhaust Emissions from Conventional and Reformulated Gasolines." In its test program, Chevron tested two gasolines in 19 vehicles and measured the resulting exhaust emissions.

Summary

The mass emissions reductions observed by Chevron, directionally, confirm the emissions reductions that can result with the use of reformulated gasolines. However, the results of the Chevron test program cannot be used to estimate the emission reductions that are expected from the Air Resources Board's (Board) Phase 2 reformulated gasoline regulations. The Chevron test fuels differ from the Board's Phase 2 reformulated gasoline in 4 of the 8 specifications (RVP, sulfur, T90, and aromatics). ARCO's EC-X gasoline more closely represents the gasolines that will be produced when the Phase 2 standards take effect. Thus, the reductions in exhaust emissions and in ozone forming potential observed by ARCO are more representative of the reductions that can be expected from the Phase 2 reformulated gasoline standards.

Discussion

The two gasolines tested by Chevron were designed to represent a typical Los Angeles premium gasoline and a Chevron reformulated premium gasoline.

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Chevron's program was designed primarily to investigate the effects of changes in gasoline RVP, oxygen content, and driveability index (DI) on emissions and on the ozone forming potential of the emissions. Other fuel properties differed nominally in the test program. The 19 vehicles were comprised of vehicles from four different catalyst technology groups: noncatalyst, oxidation catalyst, three-way catalyst, and three-way catalyst with adaptive learning systems. Chevron obtained speciated exhaust emissions data and estimated, using the Carter MIR method, the ozone forming potential of the exhaust emissions.

Chevron's conclusions are that, on average, total volatile organic compound (VOC) emissions decreased by about six percent when the reformulated gasoline was used but the specific reactivity of the exhaust emissions (expressed as grams of ozone per gram of VOC) remained approximately constant. Per mile emissions reactivity (expressed as grams of ozone per mile) was reduced by about six percent. This reduction resulted from the decrease in the exhaust mass emissions rate.

The results of Chevron's test program appear to be directionally consistent with the results of other test programs that have been conducted to investigate the effects of various gasoline reformulations on emissions. Where Chevron's results differ, the differences appear to be explainable. Directionally, the reduction in the VOC mass emissions rate observed by Chevron is consistent with the results of test programs such as the Auto/Oil program and ARCO's EC-X program. The mass emissions reductions observed by Chevron appear to be consistent with what would be predicted by the regression equations developed in the Auto/Oil program. We used the Auto/Oil regressions for the two fuels tested by Chevron and predicted about a four percent reduction in total VOC emissions for the reformulated fuel tested by Chevron as compared to the six percent reduction observed by Chevron.

The magnitude of the mass emission rate reduction observed by Chevron is also less than what was observed by ARCO. When ARCO tested the EC-X fuel against the industry-wide average fuel they observed a 37 percent reduction in the average NMOG emissions when its EC-X fuel was used. Of course, EC-X represents a more severely reformulated gasoline than was tested by Chevron.

Chevron's failure to find a difference in the specific reactivity of the exhaust emissions from the reformulated fuel conflicts with the findings of ARCO. In its program ARCO found about an eight percent reduction in the specific reactivity of the exhaust emissions from the fuel as compared to the industry average fuel.

The differences in VOC mass emission reductions and the specific reactivity reductions observed by Chevron and ARCO appear to be due to the differences between their baseline reference and reformulated gasolines. The reformulated gasoline used by Chevron was not greatly different from its reference premium gasoline. There are greater differences between ARCO's EC-X gasoline and its reference gasoline. A comparison of some of the relevant properties shown in Table 1 illustrates these differences.

Table 1. Comparison of Properties of Chevron and ARCO Reference and Reformulated Gasolines

| Property | Chevron Gasolines | | ARCO Gasolines | | ARB |
|---|---|---|---|---|---|
| | Reference | Reformulated | Reference | EC-X | Phase 2 |
| RVP(psi) | 8.5 | 7.5 | 8.7 | 6.7 | 7.0 |
| Sulfur(ppm) | 143 | 121 | 330 | 40 | 40 |
| Olefins(vol%) | 6.8 | 5.5 | 9.7 | 5.5 | 6 |
| Oxygen(wt%) | 0.5 | 2.1 | 0 | 2.7 | 1.8-2.2 |
| Aromatics(vol%) | 36 | 35.6 | 34.4 | 21.6 | 25 |
| T50 | 235 | 204 | 213 | 201 | 210 |
| T90 | 318 | 311 | 323 | 293 | 300 |
| DI | 1233 | 1126 | 1151 | 1109 | NA |

DI = Driveability Index

The above table illustrates the fact that the two fuels tested by Chevron do not differ to a great extent. This is not surprising since the main objective of the Chevron program was only to investigate the effects of reformulation by changing RVP, driveability index (DI), and oxygen content. Olefins, T90, and Sulfur content were not greatly different between the reference fuel and the Chevron reformulated fuel. Only the olefin, oxygen, and the T50 properties of Chevron's reformulated gasoline meet the ARB's phase 2 reformulated gasoline standards.

The above table also shows that the differences between the reference gasoline and our Phase 2 reformulated gasoline were much greater for the ARCO fuels than those for the Chevron fuels. The reformulated gasoline used by ARCO (EC-X) is very similar to the gasolines that will be used when the ARB's phase 2 reformulated gasoline regulations take effect. ARCO's EC-X gasoline almost meets all of the phase 2 reformulated gasoline standards, except for oxygen content. Only slight modification to the EC-X gasoline is necessary in order for it to meet the oxygen standard. The estimated emissions reductions will not be greatly diminished as a result of this modification, as the EC-X gasoline does not currently exceed the oxygen standard by very much.

Because in the Chevron test program the reformulated gasoline did not differ as much from the reference gasoline, it is not surprising that the observed VOC benefits are small and that no reductions in the ozone forming potential were observed. I hope this analysis is helpful. If you have any questions please feel free to call me at (916) 445-0650, or Dean Simeroth at (916) 322-6020.