HHA-105

Final Report: Fuel Permeation From Automotive Systems, CRC Project No. E-65

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ABSTRACT:

The California Air Resources Board (CARB), in cooperation with the Coordinating Research Council (CRC), sponsored a major study on the permeation effects of ethanol on automotive fuel systems. Permeation is a diffusion process whereby fuel molecules migrate through the elastomeric materials (rubber and plastic parts) that make up the vehicle's fuel and fuel vapor systems. Permeation is a component of the evaporative emissions from the vehicle fleet.

The need for a study of the permeation effects of ethanol became apparent when in late 1999 California banned the use of MTBE in gasolines. With this ban, which became effective starting in calendar year 2004, ethanol became the only oxygenate approved for use in California gasolines. California must quantify the permeation effects of ethanol because California's statues require that any increase in fuel emissions be off-set with a similar reduction from other sources. The year-round use of oxygenated gasoline in severe and extreme ozone non-attainment areas is a federal government requirement that applies to about 80 percent of the gasoline sold in California. The CARB petitioned the Environmental Protection Agency to waive the oxygenate requirement for California's gasoline, stating that complying gasolines could be blended without the use of an oxygenate. However, a waiver has not yet been granted.

The study was first proposed at a public meeting in Sacramento on June 21, 2001. the CRC offered to support and co-fund the program. Contracts were awarded I March 2002, but funding availability delayed the formal commitment until late in 2002.

This test program was designed to determine the magnitude of the permeation differences between three fuels, containing either MTBE, ethanol, or no oxygenate, in the selected test fleet. The testing was conducted on a sample of ten California vehicles chosen to represent the light-duty in-use fleet as it existed in calendar year 2001. The oldest was a 1978 Oldsmobile cutlass,

and the newest was a 2001 Toyota Tacoma pick-up truck. Vehicles were identified and purchased in late 2002.

The vehicles' liquid and vapor fuel systems were removed and installed on aluminum frames (rigs) for evaluation. Special care was taken to remove the complete system, without disconnecting any of the components. The rig mounted systems were stabilized at 105 degrees Farenheit with a 100% fill of each of the test fuels.

The emission tests were conducted between January 2003 and June 2004. Emission measurements included steady-state permeation rates at 105 and 85 degrees Farenheit, and 48-hour diurnal measurements using the California test procedure (65 to 105 to 65 degrees Farenheit). All emissions samples were analyzed for hydrocarbons and specific oxygenates, and average reactivities were calculated from the speculation results for all three fuels. Repeat diurnal tests were performed using the non-oxygenated fuel to establish an estimate of the repeatability of the experiment. The coefficient of variation (COV) (standard deviation/mean level) for the diurnal results was estimated at 8%.

Emissions increased on all 10 vehicle fuel systems studied when ethanol replaced the MTBE in the test gasolines. The average permeation emissions with a 5.7 volume % ethanol gasoline were 1.40 grams/day higher than permeation emissions with the MTBE gasoline and 1.10 grams/day higher than permeation emissions with a non-oxygenated gasoline. This is equivalent to an average permeation emissions increase of 65% with a change from the MTBE gasoline to the ethanol gasoline and 45% with a change from the non-oxygenated gasoline to the ethanol gasoline. The average permeation difference between the MTBE fuel and the non-oxygenate fuel was .030 grams/day. The difference between the ethanol fuel and the others are statistically significant at the 95% confidence level. The differences between the MTBE and the non-oxygenated fuel are not statistically significant. The results of this study apply to 5.7% ethanol blended gasoline as used in California, but may not necessarily apply to higher concentration ethanol blends or different gasoline compositions. This report, with detailed results of the test program has bee posted on the CRC's web-site at www.crcao.com and on CARB's web-site at www.arb.ca.gov/fuels/gasoline/gasoline.htm.

The rigs with non-metallic fuel tanks were evaluated to determine if permeation emissions varied with fill level. The base program stabilized the permeation at 100% fill. Additional testing was performed at 20% fill. Mixed results were obtained – the newer systems had less permeation after the 20% stabilization; he mid-90s tanks had little effect or an increase.