APPENDIX F

Effects of Changes in Diesel Fuel Properties on Emissions

The Effects of Changes in Diesel Fuel Properties on Emissions

Recent studies have shown other diesel fuel properties (e.g., fuel density, T50, and T90) that are not included in the California diesel fuel regulations can also affect two primary diesel engine emissions, NOx and PM10.

The U.S. EPA has developed regression models that relate fuel properties to engine emissions. Staff used a NOx model[1] (see Appendix D, Table 8, EPA Model), as follows:

NOx (g/bhp-hr) = exp(0.50628 - 0.002779*Cetane Difference + 0.002922*Aromatics + 1.3966*Specific Gravity-0.0004023*T50) ………………………Eqn [1]

This equation was used to demonstrate the effects of specific gravity (density) and/or aromatic content (vol%) changes on NOx emissions. Particularly, Eqn [1] was used to compare NOx emissions from new fuel specifications to a baseline or reference fuel such that the ratio would describe how much new fuel emissions increase or decrease relative to the baseline fuel. If all other properties are the same, except specific gravity, Eqn [1] can be simplified, as follows:

Ratio = exp(1.3966*Delta Specific Gravity)……………………………………………Eqn [2]

where delta specific gravity is the difference in specific gravity between new and baseline fuel.

Figure 1 exhibits specific gravity and NOx emissions change relationship. The slope of this graph explains how much reduction in specific gravity for one percent decrease in NOx. From the figure, it can be seen a 0.007 decrease in specific gravity reduces NOx emissions by about one percent. Similarly, Figure 2 shows aromatic content (vol%) and NOx emissions relationship. On average, every one percent of NOx emissions decrease is associated with a 3.4 volume percent reduction of aromatic content. In a more complex case, the model could also be used to find a trade-off between fuel density and aromatic content to maintain the same NOx emissions, as shown in Figure 3.

Similar results were also found using a NOx model developed by the U.S. EPA Heavy-Duty Engine Working Group (HDEWG)[2] (see Appendix D, Table 8, HDEWG Model), which employed different form and used slightly different independent variables, shown below:

NOx (g/bhp-hr) = -1.334 + 0.00646*Mono Aromatics (wt%) + 0.00763*Poly Aromatics (wt%) + 4.13*Specific Gravity + 0.00337*Cetane Number…………………Eqn [3]

All else equal, using Eqn [3] it can be shown that a 0.006 (compared to 0.007 in Eqn [1]) decrease in specific gravity reduces NOx emissions by one percent.

[1] Adopted from the U.S. EPA's staff discussion document*, Strategies and Issues in Correlating Diesel Fuel Properties with Emissions*, Table III.B.3-2, page 30

[2] Mason, R.L., et al., *EPA HDEWG Program – Statistical Analysis,* SAE Technical Paper No. 2000-01-1859, June 2000.

Figure 1. Diesel Fuel Specific Gravity and NOx Emissions Relationship (U.S. EPA Model)

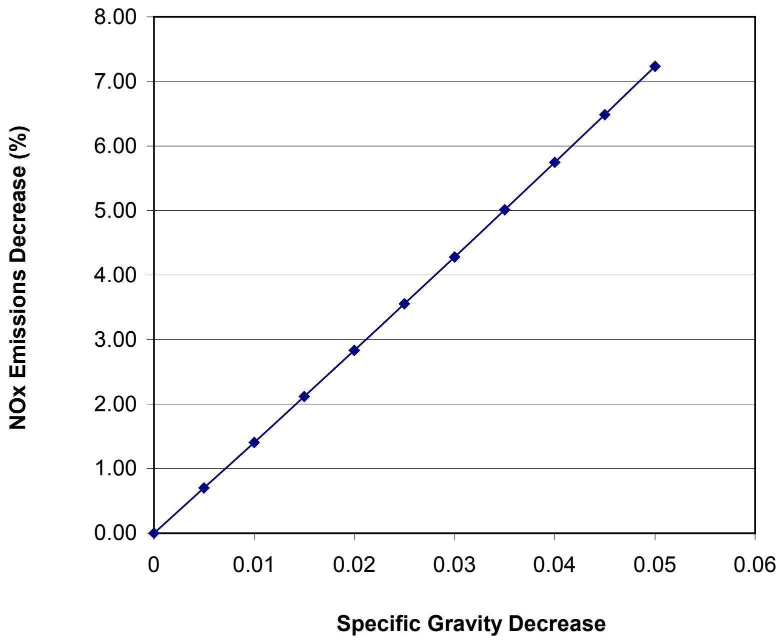

Figure 2. Diesel Fuel Aromatic Content and NOx Emissions Relationship (U.S. EPA Model)

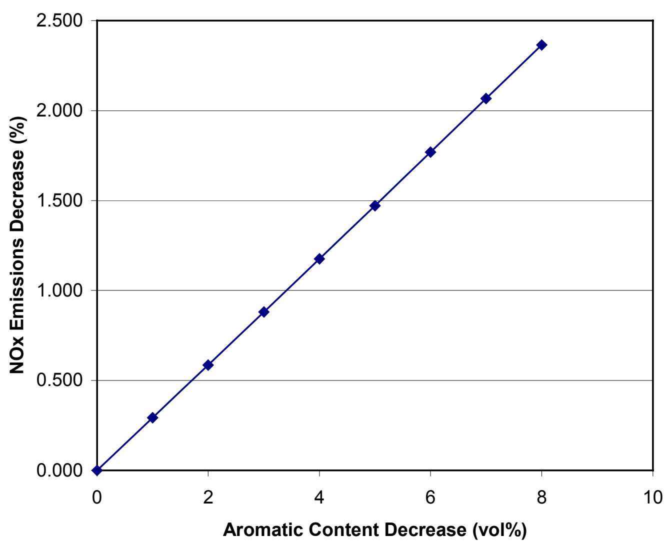

Figure 3. Diesel Fuel Density and Aromatic Content Trade-Off for NOx Emissions Equivalency (U.S. EPA Model)