EFFECTS OF OXYGEN ON EXHAUST CO EMISSIONS

SUMMARY OF A DRAFT PROPOSAL FOR MOBILE6

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Objectives:

- To develop a more accurate estimate of the effects of oxygen and oxygenates on exhaust emissions of CO

- To more accurately match model estimates to ambient CO data than the current MOBILE estimates

Ambient Data:

- The following table, which summarizes changes in CO associated with oxyfuels in analyses of ambient data, was reprinted with permission from the following document:

  Cook, R., Enns, P., Sklar, M. S. "Statistical Analyses of the Impact of the Oxyfuel Program on Ambient CO Levels." Submitted for proposed book Impact of the Clean Air Act on Fuels Production and Use, D. Cronauer, John Reynolds, Rashid Kahn, eds.

Study	Adjustment for Meteorology?	Geographic Area	Change in CO associated with Oxyfuels (%)
CARB (Dolislager, 1997)	Yes	California	-5 to -10
CDC (Mannino & Etzel, 1996)	Yes	Western States	-10
University of Colorado (Wolfe et al., 1993; Wolfe et al., 1994; Anderson et al., 1994; Wolfe et al., 1996; Anderson et al., 1997a,b; Anderson et al., 1997c)	No	Denver, CO Albuquerque, NM Phoenix, AZ Las Vegas & Reno, NV	+19 to -16*
Desert Research Institute (Keislar et al., 1997)	No	Provo, UT	-9 to -15 (traffic site) -15 to -35 (parking garage)**
North Carolina (Vogt, 1994; Cornelius, 1995)	No	Durham, Forsyth, and Wake Counties in North Carolina	not quantified

EPA (Cook, Enns, & Sklar, 1997)	No	Nationwide	-7 to -11
SAI (Whitten, Cohen, & Kuklin, 1997)	No	Nationwide	-11 to -17
AIR (Kahlbaum & Rykowski, 1997)	No	Nationwide	-10 to -15

* Results not significant at any site except Phoenix, with a 16% reduction
** Results not statistically significant

- The average of all the numbers in the last column is about a 15% reduction

Preliminary Comments on Analysis:

- Nationwide CO non-attainment problems diminishing
- We would like to keep the analysis for computing exhaust CO effects based on oxygen addition as simple as possible, without losing a great deal of accuracy

Analysis on post-1987 vehicles:

- We propose that the CO exhaust emissions model be used to predict oxygen and associated impacts on CO emissions as a function of emitter class
- This model is based on data collected on "1990 technology" vehicles--same as the complex model database
- The methodology used to construct the model is very similar to that used to construct the complex models for VOC and NOx
- This model has been peer reviewed and is published as SAE technical paper 961214
- The effects computed using this model are shown below

Analysis of pre-1987 but post-1981 vehicles:

- We propose that the recently completed ARCO analysis be considered for use here once it has been appropriately reviewed
- This analysis is based on the ARB database for older vehicles (model years 1981-1987); this data was used to generate a model capable of predicting CO emissions as a function of fuel parameters
- Higher emitters were not treated as a separate group of vehicles in this analysis

- A methodology very similar to that used to develop the model in SAE paper 961214 was employed
- Numbers from this analysis are also summarized below
- As an alternative, the current MOBILE estimates can also be used to estimate the effects from these group of vehicles

Analysis of pre-1981 vehicles:

- Propose to use the current estimates in MOBILE for this group of vehicles
- These estimates are based on a 1988 Technical Report entitled "Derivation of Technology Specific Effects of the Use of Oxygenated Fuel Blends on Motor Vehicle Exhaust Emissions" (EPA-AA-TSS-PA-88-1)
- The contribution of these model year vehicles to in-use emissions is quickly diminishing and the effect (however large) will not play a major role in determining overall oxygen effects on any current or future in-use fleet calculations
- The specific effects for this class of vehicles is also summarized below

Specific effects of oxygen addition on CO emissions:

- The following draft table summarizes the exhaust CO model, the ARCO analysis, and MOBILE for their predictions of how oxygen effects CO emissions:

Model Evaluated	Percent Reduction in Exhaust CO Emissions Accounting for All Fuel Parameters Upon Addition of Oxygenate			
	Typical 2.7 weight % MTBE		Typical 3.5 weight % ETOH	
CO Exhaust Emissions Model "1990 Technology" Vehicles only Published as SAE Paper 961214	Normal	Higher	Normal	Higher
	13.8	9.33	15.4	10.1
Proposed ARCO Analysis/Model Not yet reviewed 1981-1987 Model Years Covered	18.2		19.1	
MOBILE5 for Model Year 1980	21.0		28.0	

Proposed procedure for revising CO effects:

- For simplicity, it is assumed that oxygen's effect on exhaust CO emissions is invariant of emissions type. The effects are assumed to be constant for start, running and composite emissions (which is the variable analyzed in the analyses shown in the above table)

- The "All Fuel Parameters" column in the above table refers to changes in all fuel parameters upon addition of oxygenate due to dilution. Typical 2.7 weight percent MTBE and 3.5 weight percent ethanol fuels were used (part of ARCO analysis)

- Keep current options for the user input structure the same. The numbers proposed will be developed from the entries in the above table, to better capture oxygen's effects on CO emissions

- All relationships between oxygen and CO emissions are linear

- Due to lack of well-controlled data, and as supported by the analysis in SAE technical paper 952403 by Hood and Farina, we propose that percent changes (CO effects) at colder temperatures remain unchanged from ambient effects (as is the case in the current MOBILE model). We request your comments specifically on this issue.

- There has been some recent testing conducted by EPA's Office or Research and Development on cold temperature CO/oxygen effects using various vehicle technologies. These numbers have yet to go through rigorous review, however. Once these numbers have been reviewed, and if time permits, they will be considered in the analysis for computing cold temperature effects of oxyfuels on CO emissions in MOBILE6.

- Our overall proposal is to use effects calculated by the exhaust CO model for post-1987 vehicles (which are split into two emitter categories), ARCO's analysis for 1981-1987 vehicles (as long as it is reviewed), and MOBILE5 estimates for pre-1981 vehicles. MOBILE6 will internally weight them appropriately for the calendar year that needs to be evaluated.

- For the 1990 model year, this methodology results in an approximate oxyfuel benefit of 14.3% for 2.7 weight percent oxygen blends and 16.1% for 3.5 weight percent oxygen fuels (this compares to a 23% reduction estimated for 2.7 wt% fuels and a 30% reduction estimated for 3.5 wt% fuels with the current MOBILE model for 1990)