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Estimating Emission Effects of RFG Gasoline in MOBILE6

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1.0 INTRODUCTION

Reformulated gasoline (RFG) is an EPA rule that affects the properties of gasoline fuels in regions where RFG is required beginning with the 1995 calendar year. These fuel properties affect the exhaust and evaporative emissions from all gasoline fueled vehicles within the region. Details about this rule can be found on the EPA web site:

http://www.epa.gov/otaq/rfg.htm

The MOBILE5 model accounted for the effects of RFG by adjusting the fuel properties available in MOBILE5 (i.e., Reid vapor pressure (RVP) and oxygen content) and then adding a multiplicative adjustment factor to account for all other remaining fuel properties (i.e., sulfur content, etc.). Since MOBILE6 now includes fuel sulfur content explicitly, MOBILE6 will be able to account for RFG directly by adjusting levels of RVP, oxygen content and sulfur content of the fuel. Other fuel properties affected by RFG, which mainly affect exhaust toxic emissions not included in the output of MOBILE6, will not be modeled. The multiplicative adjustment factor approach used in MOBILE5 will no longer be needed.

It should be pointed out that MOBILE6 is not a complete fuel properties model. A much more detailed evaluation of fuel effects on emissions is possible using tools such as the Complex Model developed for use by refiners for the Reformulated Gasoline rule. MOBILE6 attempts to capture only the gross effects of in use fuels on the full highway mobile source fleet for purposes of inventory estimates.

Other reports, listed in the references, address the effect of specific fuel parameters on emissions. This information is not repeated in this report. This report addresses only how the existing fuel parameter capabilities of MOBILE6 are used to account for the effect of RFG on emissions. RFG will only affect gasoline fuel properties and the emissions from gasoline fueled vehicles, including light-duty, heavy duty and motorcycles, in MOBILE6.

2.0 BASE FUEL PARAMETERS

MOBILE6 assumes that the effective RFG fuel formulation is the same in all areas. The rule itself requires a performance standard, meaning that the precise formulation of RFG will vary from refiner to refiner, but the overall effect (performance) will be similar in order to comply with the emission reduction targets. For MOBILE6 a specific RFG formulation is used for each phase, RFG region, with different composition assumptions for winter and summer. Although the actual RFG used in an area may not match the formulation assumed by MOBILE6, the overall performance should be similar. The following tables list the overall fuel parameter assumptions used for MOBILE6 when RFG is selected. Note that MOBILE6 does not explicitly model all of the fuel parameters specified by the RFG rule. While the exact composition of RFG fuel may vary by refiner; the RFG fuel values modeled in MOBILE6 are consistent with the RFG requirements, and represent the typical values expected in an RFG area.

The Clean Air Act defines the RFG "summer" as May 1 through September 15. "Winter" is the rest of the year. MOBILE6 will determine which fuel season to model using the value input for evaluation month (1 = January, indicates winter; 7 = July, indicates summer). However, the user will be able to override the fuel season indicated by the evaluation month by using the "season" command, if necessary.

MOBILE6 Default Seasonal Variation in Reformulated Gasoline		
Season	Summer*	Winter**
Month (MOBILE6 code)	July (7)	January (1)
Ethanol Market Share	0.0%	30.0%
Ethanol Oxygen Content (by weight)	N/A	3.5%
Ether Blend Market Share	100.0%	70.0%
Ether Blend Oxygen Content (by Weight)	2.1%	1.5%
Reid Vapor Pressure Waiver	N/A	Yes
Fuel Reid Vapor Pressure	Fixed	User Supplied

* User supplied RVP and oxygenated fuel program parameters are ignored in summer when Reformulated Gasoline is specified.

** Default oxygenated fuel program parameters can be overridden by the user in winter if the market share for oxygenated fuels is 100% and the combined oxygen content is at least 2.1%

Note that, in summer, MOBILE6 assumes that all of the oxygen content of the fuel comes from ether blends. A market share including ethanol could also have been used (as long as there was no Reid Vapor Pressure (RVP) waiver) and the effect on emissions would be the same. Using ethanol and allowing an RVP waiver in summer RFG would cause the evaporative emissions of vehicles to increase and would not be consistent with RFG rules regarding overall emission reduction performance. Allowing some fuels to contain ethanol and some fuels to use ether blends would cause "commingling" effects on RVP, which also would not be consistent with RFG rules. If RFG is selected, the user may not override the oxygen program parameters in summer. Any user inputs for an oxygen program in RFG areas in the summer will be ignored and have no effect.

Note that the RVP of RFG in summer is determined by MOBILE6. If RFG is selected, the user supplied value for RVP will be ignored in summer months of calendar years when RFG is in effect.

Note that, in winter, however, the user may specify a particular oxygenated fuel program whose values will override the MOBILE6 default program described in the table, if the overall oxygen content of the program is at least 2.1% and the combined market share for oxygenated fuels is 100%. RFG requires that oxygenated fuels be used year round.

The fuel volatility in MOBILE6 is specified by the Reid Vapor Pressure (RVP) measured in pounds per square inch (psi). The RVP selected for summertime RFG varies by calendar year, beginning with calendar year 1995, when the RFG program began, and changing in calendar year 2000, when phase two of the RFG program began. The RVP values change again in 2003 to reflect the mandatory change in fuel sulfur content due to the Tier 2 rule (described below). Like conventional gasoline, RFG must meet fuel volatility requirements that vary by geographic region. See the list of references for guidance on selecting the RFG region for your area.

Summer Reformulated Gasoline Fuel Reid Vapor Pressure for MOBILE6						
Calendar Years	1995 -1999		2000 - 2002		2003 and Later	
Fuel Region	Region 1 (South)	Region 2 (North)	Region 1 (South)	Region 2 (North)	Region 1 (South)	Region 2 (North)
Reid Vapor Pressure (psi)	7.1	8.0	6.7	6.7	6.8	6.8

Note that, in winter, MOBILE6 will not specify the Reid Vapor Pressure (RVP) and the user supplied values will be used. RFG does not require that refiners control RVP in winter.

Fuel sulfur content is specified in MOBILE6 in units of parts per million (ppm). The fuel sulfur content selected for summertime RFG varies by calendar year, beginning with calendar year 2000, when phase two of the RFG program began. Before calendar year 2000, the sulfur content of RFG is assumed to be the same as the default value (300 ppm) or the value specified by the user for that calendar year.

In an RFG area, for calendar years before 2000, the user may specify a sulfur content value which will override the default average fuel sulfur level of 300 ppm. In calendar years 2000 and later in RFG areas, the sulfur content of fuel is specified by MOBILE6 as shown below, which is consistent with the specific fuel formulation assumed for RFG in the model, and cannot be changed by the user. In calendar years 2000 and later, the sulfur level of the fuel is assumed to be controlled in both winter and summer seasons.

The “Maximum Sulfur” values listed below and used in MOBILE when the RFG option is selected are appropriate for most of the United States, but they are not accurate for Alaska, Colorado, Idaho, Montana, New Mexico, North Dakota, Utah, and Wyoming (western Tier 2

Reformulated Gasoline Sulfur Content for MOBILE6				
	Summer (Month of July)		Winter (Month of January)	
	Sulfur Content (ppm)		Sulfur Content (ppm)	
Year*	Average	Maximum	Average	Maximum
1995-1999	300	N/A	300	N/A
2000	150	1000	300	1000
2001	149	1000	299	1000
2002	129	1000	279	1000
2003	120	1000	259	1000
2004	120	303	121	303
2005	90	303	92	303
2006	30	87	33	87
2007	30	87	33	87
2008 and later	30	80	30	80

*For "Average Sulfur" levels the year listed here indicates the *calendar year* for which the average sulfur level is typical. However, the "Maximum Sulfur," value represents the maximum sulfur level ever experienced by a vehicle of that model year, regardless of the current fuel level in the calendar year of the MOBILE run. Thus, the "year" in these tables is used to assign the "Maximum Sulfur" values to the appropriate vehicle *model year*. (Note, the maximum sulfur effect is not calculated for 1999-and-earlier model year vehicles, so no maximum sulfur level is needed for these years.)

sulfur content phase in states), since these states are allowed a different phase in for Tier 2 fuel parameters beginning with calendar year 2000. For calendar year 2000 and later calendar years, these areas will need to model RFG directly by specifying the fuel parameters of RVP, oxygen content and sulfur content (both average and maximum) appropriate for each calendar year and will not be able to use the RFG option available in MOBILE6.

The default values for RFG are supplied in MOBILE6 in order to assist users in modeling emissions in RFG areas. If an RFG program is desired with fuel parameters other than those specified by MOBILE6 as described above, the user must carefully choose values for gasoline RVP, oxygen content and sulfur content (both average and maximum) appropriate for each calendar year to be modeled. These fuel parameters must be consistent with the final RFG rule in terms of overall emission performance.

3.0 REFERENCES

"Fuel Sulfur Effects on Exhaust Emissions: Recommendations for MOBILE6," (M6.FUL.001, EPA420-P-99-008). (see: http://www.epa.gov/otaq/m6.htm)

"Fuel Oxygen Effects on Exhaust CO Emissions," (M6.FUL.002). (see: http://www.epa.gov/otaq/m6.htm)

"Volatility Regulations for Gasoline and Alcohol Blends Sold in Calendar Years 1992 and Beyond," 55 FR 23658, June 11, 1990.

"Guide on Federal and State RVP Standards for Conventional Gasoline Only,", (EPA420-B-00-004) March 2000. (see: http://www.epa.gov/otaq/fuels.htm)

"Guidance on Use of Opt-in to RFG and Low RVP Requirements in Ozone SIPs," August 1997. (see: http://www.epa.gov/otaq/fuels.htm)

Documents related to the Tier 2 rule and its affects on Reformulated Gasoline, (see: http://www.epa.gov/otaq/tr2home.htm#documents)