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Technical Note

Date: January 11, 2012

To: Brian Menard, SRA International, Inc.

From: Rob Klausmeier, de la Torre Klausmeier Consulting, Inc.

Subject: **Peer Review of *DELTA Model: Improved Evaporative Emissions Modeling for EPA MOVES***

As requested by SRA International, I have performed a peer review of the above mentioned report. I have been involved in mobile source emissions modeling since 1985. I managed the development of the CRC Evaporative Emissions Model, which had many elements that were used in later versions of EPA's MOBILEx models. I do not have any real or perceived conflict of interests with MOVES or the DELTA Model.

The report is well written; it clearly described the complex process of modeling vehicle evaporative emissions. Although I have several comments, I believe the DELTA model is significant enhancement to MOVES. Following are my comments on the report:

1. Section III.

   "*Ethanol effects vary in that vapor evaporation increases as ethanol concentration increases until approximately 15% ethanol content. At higher concentrations evaporation decreases with increasing ethanol due to nonlinear effects on fuel volatility, with volatility returning to E0 levels around 50% ethanol content and decreasing from there.*"

   Please provide a reference for the statement concerning the impact of increasing ethanol content on fuel volatility.

2. Section III.b.ii

   "Canister adsorption is also affected by the temperature of the canister as well as the rate of vapor loading onto the canister. Activated carbon adsorption rates are inversely proportional to the temperature of the carbon bed. As the temperature of the canister rises, the rate of adsorption decreases while the rate of desorption increases. This has the effect of lowering the BWC with higher temperatures."

   Can the authors provide rough estimates of the relative impact of temperature on butane-working capacity for the canister? The temperature effect may have a big impact on emissions during 2nd, 3rd, and subsequent days of a multi-day diurnal. If the impact is significant, EPA may want to model the impact in MOVES or in DELTA.

3. Section III.b.ii

   "*Canister loading does not occur linearly throughout the carbon bed. While it is convenient to think of vapor loading into the canister similarly to a glass filling with water (and eventually overflowing when the glass is full), fuel vapors form a concentration gradient throughout the carbon bed. During short term loading events (such as ORVR), the fuel vapor does not have sufficient time to spread into a gradient before a clean-out event takes place. However, a diurnal lasting several days provides ample time for some vapor to move beyond the front of high concentration near the inlet to the canister.*"

   It is not clear if the bleed effect applies to the example of short-term loading events, such as ORVR, or multi-day diurnals. In addition, the magnitude of the bleed affect should be discussed, if it's significant.

4. Section III.b.ii

   The statement in the above quote concerning short-term loading effects, such as ORVR cases, raises the question about multi-day diurnal emissions after such an event. If, for example, the vehicle is refueled and then parked for several days, it's possible that available canister capacity will be lower than expected. This might be something EPA might want to explore either in MOVES or in the DELTA model.

5. Section III.c

   "Durring the cooling phase of a diurnal, fresh air from the atmosphere is drawn back into a vehicle fuel tank and across the carbon bed in the canister."

   The sentence has a typo in the word "during." Also, the statement is made that fresh air from the atmosphere is drawn back into the vehicle fuel tank and across the carbon bed in the canister. I think what the authors are referring to is canister backpurge where fresh air is drawn across the canister and into the vehicle fuel tank.

6. Section IV.b

   "DELTA uses the same weighting factors applied to the single vehicle TVG – TVV curves to calculate a single weighted tank size and canister size based on the individual tank and canister sizes found in the fleet. These weighted average tank and canister sizes are then used in the fleet average model in a similar way to how they would be applied in the single vehicle models."

   A description should be provided on how weighted average tank and canister sizes were derived. This could be done as an appendix to the report or as a reference to another report. The source of the average tank and canister data should be provided. Is it from certification data or other sources? In addition, I was curious if the average tank and canister sizes varied by model year within a technology group.

7. Section IV.b

   "Cases such as a small number of passenger vehicles modeled in the same group as a large number of pickup trucks may produce larger breakthrough than expected due to a large average tank size producing high amounts of vapor while coupled with less storage due to a smaller average canister capacity. One vehicle breaking through significantly before other vehicles in the aggregate model may also cause higher than expected breakthrough due to a small but non-zero fleet average TVG – TVV line occurring well before the average canister capacity of the fleet is reached. Usually, tank volume and canister capacity are well correlated over an entire model year fleet and therefore the tank volume and canister capacity simplifications should largely not affect results."

   Can EPA certification data to determine relative number of these cases? Also, can the authors provide an estimate of the impacts of these situations? The authors further state that tank volume and canister capacity are well correlated, therefore, the tank canister simplification should not affect results. I think this is a key point and therefore should be supported by some data, such as a plot of canister capacity versus fuel tank capacity, based on certification data.

8. Section V.b

   "Note the above figure represents the reconstructed version of the original E77 data for the vehicle shown previously in Figure 14."

   Do the authors mean Figure 13?

9. Section V.c.

   The authors compare the actual behavior using test results from CRC's E77 test program with theoretical behavior based on the DELTA model. The authors note that in most cases, the DELTA under predicts breakthrough emissions. The authors then proceed to explain the differences:

   "A more thorough analysis of E77 vehicle breakthrough was completed to explain the differences seen between the ideal model and what was happening in real world testing. It is important to note that the preconditioning procedure performed on the E77 vehicles to ensure adequate purge between tests, while meant to emulate a standard FTP cycle, was performed on public roads with variable weather conditions. This real-world preconditioning may have contributed to the non-ideal behavior seen in the data. For each test conducted in the E77 multi-day diurnal study, the canister breakthrough point (which was determined as the point at which more than 2% of the total canister capacity had escaped the vehicle canister) was compared against the theoretical capacity for the canister on that particular vehicle. The results of this analysis are shown in the following tables, separated by certification class."

The tables that follow only present information on canister capacity, when breakthrough occurs, and the percent of rated capacity. The authors should investigate and identify vehicle factors that explain the loss of canister capacity, e.g., age, mileage, temperature, and possibly year, make and model. If factors cannot be identified, the authors should state so.

10. Section VI

"Based on the results for each of the test/vehicle combinations from the E77 program, the TVV/TVG values were averaged across all 23 test/vehicle combinations to result in a single graph representing all of the Enhanced/Tier 1 vehicles."

Information on the breakdown on the types of vehicles in the different technology categories would be useful in validating whether differences between theoretical versus actual values should be averaged or some weighting should be applied. For example, if a certain vehicle model that is much more prevalent in the fleet shows more deterioration, then results for that model might be given greater weighting.

Also, the authors should investigate the sensitivity of assuming a single graph over a multi-day diurnal. The impact of canister deterioration will be much greater on 2^{nd}, 3^{rd}, and subsequent days of a multi-day diurnal than on the 1^{st} day. It may be necessary to add a time factor to the correction of DELTA for non-ideal behavior.

11. General Comment

The report does not mention how vehicles with tampered or inoperative evaporative systems are modeled. I assume that they are modeled as TVV/TVG = 1.