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June 5, 2015

Mr. Larry O'Rourke
ICF International
100 Cambridgepark Drive, Suite 500
Cambridge, MA 02140

RE: Peer Review of Report

Dear Mr. O'Rourke:

Please find attached my comments on the documents relating "Speciation Profiles and Toxic Emission Factors for Nonroad Engines Report". I work as a research engineer for the University of California at Riverside, CE-CERT and have no real or perceived conflict of interest related to this evaluation. I have considerable expertise in emissions testing and have conducted a number of major emissions test programs related to the topics presented in this report. Please let me know if you would like further information or have further questions relating to my comments, or would like to discuss the comments via a conference call.

Regards,
Tom Durbin, Ph.D
Research Engineer
University of California
CE-CERT
Riverside, CA 92521

General Summary

Specific comments

1.0 Introduction – footnote A is worded very awkwardly... “incorporated onroad and the NONROAD model”...

Section 1.2

End of 1st paragraph – The current regulation under 1065 require a 2.5 micron cyclone for PM measurements. So, is PM as defined as material collected on a filter using EPA-defined sampling practices thus defined as PM2.5.

4th paragraph – 2nd sentence – The second sentence needs to be clarified about how.... PM2.5 speciation from nonroad sources continue to be conducted in SMOKE with the use of MOVES2014a. What is MOVES2014a used within the SMOKE model. Also, a reference to SMOKE should be given.

Section 1.3

References 3,4,5, which represent the heart of the report, do not seem to be as complete as they should be. Are these documents publically available? Was a report ever done for the 2004 studies? Did they get document numbers? Can someone put these document/work assignment numbers into a web search and find these documents readily?

Section 2.1

The sentence about Equation 2 – The sentence implies that the derivation of VOCs from NMOG by removal of ethane and acetone is clearly defined in the introduction, but the NMOG/ethane/acetone combination is not really alluded to in the introduction.

Equations 3 and 4 need better clarification. Such as, the PAH gaseous and particulate emissions factors are those for the ith species. Also, the term “emissions factor” seems to really be a “fraction”.

Section 2.3

3rd paragraph – It talks about using a fuel economy estimate of 17 mpg. A description of where the 17 mpg number is from should be given (just one sentence), and a reference or footnote.

For this and section 2.4, in deriving nonroad emissions factors for metals and dioxins and furans from onroad emission factors, an important consideration should be whether the source has or does not have a catalyst. With the onroad sources predominantly being catalyst equipped, it seems like some discussion should be given on this point. This does not necessary mean that the emissions rates would be significantly higher for these emissions for the nonroad sources without catalysts, but it just seemed like some related discussion would be worthwhile.

Section 3.1

In terms of the estimates for Tier 4 nonroad engines, it is important to point out that the emissions standards are slightly looser than those for the corresponding 2007+ model year onroad engines. Thus, it is my understanding that DPFs are not as universally applied as for the onroad vehicles. While ACES data for newer onroad engines is probably the best estimate for filling in data for Tier 4 nonroad engines, some explanation of this caveat should be included in this report, as it is an important distinction.

Paragraph 5 – It says NMHC is derived from equation 1, but equation 1 is for NMOG, so some discussion of rearrangement needed to get NMHC should be provided.

It seems commas could be added to the final sentences in both paragraph 5 and 6. Paragraph 5 .. , as document in.... Paragraph 6 , which is listed ...

Section 3.2

1st paragraph final sentence Represent partitioning as seen in the sampled diluted exhaust,

Section 3.3

In the first paragraph, it talks about studies used in developing onroad emissions factor and study specific fuel economy estimates are outlined in the notes of Table 13. I don't see any of that information in Table 13 and it would be useful. This could include some information in the footnotes.

Section 3.4

3rd paragraph – (75hp) add space to (75 hp)

Appendix A

It seems like the numbering system for Appendix A should be different than that used in the main test. Maybe call the section A-1.0 Introduction.

In paragraph 2 of Introduction 1.0, the references 3,4,5 should be superscripted.

Some of the text near the end of the 2nd paragraph on CMAQ/SPECIATE might be worth adding to the main text to strengthen the introduction.

Section 2.1.2

A reference should be added for the ARB study that is discussed in the 1st paragraph.

Section 2.1.3

Paragraph 2. Why were the FTPs for the ATVs and motorcycles run as 4 bag as opposed to 3 bag FTPs.

Paragraph 3. A little more detail should be given on the Phase II Auto-Oil methods for the 4 methods used for C₁-C₄, C₅-C₁₂ species (include subscripts), benzene and toluene, and alcohols.

Section 2.1.4

It would be worthwhile discussing a bit more about how many replicate tests were conducted for the different tests.

Paragraph 4 – Is an array of impingers 2 or more impingers?

Section 3.1

At the end of the 2nd paragraph, it talks about there being no outliers, but it then goes on to discuss data adjustments in the 3rd paragraph.

Final paragraph – It indicates that the 2-stroke catalyst data were not utilized due to various issues with the data. First, it would be useful to know how common or what percentage of the nonroad population are 2-stroke catalyst engines, and where would they most commonly be used. Secondly, for the abnormalities in the data, could some of this be due to making measurements at very low emission levels. For example, are the numbers for the abnormalities still much lower than those for the uncatalyzed 2-stroke engines?

Section 3.2

2nd paragraph – 1st sentence ...transient data would be used Should be written..... transient data was used. Also +50 hp (a space is needed).

4th paragraph right below Table 3-3. It talks about zeroing out a high acetylene value. Doesn't this wind up biasing the 1.15% average low? Maybe it rather be not available (NA) as opposed to being zeroed.

Section 4

The reviewer agrees that data on toxic emissions from NGVs is limited, hence necessitating the use of on-road emissions factors. So this seems to be a reasonable estimate to make. In addition, to the source that is cited in the report, additional data on a subset of toxic species should be available from recent work done by UCR as part of a series of programs that have been conducted to evaluate the effects of varying natural gas fuel composition on emissions. These studies focused on measuring just carbonyl species. Additionally, West Virginia University (WVU) conducted some studies of NGVs that included some toxics measurements, such as BTEX species and carbonyls. It is expected that more work in characterizing CNG emissions from heavy-duty vehicles will be conducted over the next several years as part of additional efforts that are being planned in California.

Sections 4.2 and 4.3 both reference emission factors from the onroad air toxics report. I expect that these also originate from reference 22, but that reference should be included in both sections as the original source of the raw emissions data. It is worth noting that we also conducted some analyses on some of our filters from NGV testing, but no PAHs were detected with the level of sample collected, as these runs were not designed to be elongated to collect higher levels of mass.

The reviewer agrees that dioxin and furan emissions are probably not available for natural gas engines, and the estimates from the onroad gasoline vehicles seems as reasonable as any.

It is worth noting that if it is desired to obtain additional toxics data from natural gas vehicles that the addition of these measurement to the upcoming California efforts to study natural gas vehicle emissions could be considered.

Section 5

It is agreed that there is an absence of toxics data from LPG nonroad engines, and that estimates based on onroad vehicles are needed to fill this category. Profiles developed from the 3 light-duty LPG vehicles are probably not terribly representative of nonroad engines, even if these data may be the only available. It should be worth mentioning that utilizing emission factors from catalyst-equipped vehicles could under report the toxics for engines without catalysts. It might also be useful to compare the relative hydrocarbon levels from the light-duty vehicles to those of some recent testing of LPG heavy-duty vehicles conducted at UC Riverside. It would also be useful to provide the reference of the original source data from which the 3 light-duty LPG vehicles was derived. In the absence of data for PAHs, metals, and dioxins and furans, utilizing estimates based on the CNG engines seems reasonable.

Section 6

Toxics measurements of evaporative emissions are relatively limited. The EPA was a part of the most recent E-77-2b test program on permeation emissions. For the permeation emissions, there is a good discussion of some of the limitations that tank and hose permeation are not differentiated in the onroad portion of MOVES. For section 6.1 on the vapor venting and refueling emissions, the data date back to the early 1990s. It would be useful to reference the original Auto/Oil source materials as well as the Environ study. I thought that studies of evaporative emission toxics were also conducted by EPA in a similar timeframe, although these are quite old as well. I have included a list of some of these older references at the end of this document.

Section 7

The approach for developing the crankcase running exhaust emissions from the onroad gasoline and diesel engines profiles seems to be a reasonable methodology. In terms of explanation, some of the details are provided in Sections 2.1 and 3.1. The crankcase to exhaust ratios are the other key piece of information in developing these emissions factors. Although these are included in this document by reference, it really would be useful to have some values for the ratios for at least THC in this document as well, as this provides an important context for understanding the air toxic emission factors in this report.

Some clarifications could be added to the PAH section. It seems reasonable to use the gaseous phase PAH fractions from Table 7 and 12. One question about this methodology is how the distribution of gaseous VOCs might change between gaseous exhaust emissions and vapor from lubricant oil.

It seems unlikely that there would be significant metal or dioxin/furan emissions from the lubricant oil, so the assumption that these emissions would be negligible in comparison with exhaust emissions seems reasonable.

Charge Questions

1. Does the presentation describe the selected data sources sufficiently to allow the reader to form a general view of the quantity, quality and representativeness of data to be used in the development of emission rates? Are you able to recommend alternate data sources that might better allow the model to estimate national or regional default values?

Overall, speciation data from nonroad sources are pretty limited, so the data sets identified and utilized appear to be good selections in terms of developing the speciation profiles. Two other questions of importance are how representative are these data, and what areas should EPA be looking to collect data in the future.

In terms of the representativeness of the data, it might be useful to discuss in the document how representative the data are in describing the data sources. For example, for the NRMHC and ATVs, the data set did not include any 4-stroke NRMHC/ATVs. While 4-stroke represent a smaller percentage of the overall sales, it would be useful to provide or obtain information on what percentage of these vehicles are actually 4-stroke, and as such not accounted for. This could be more important for the nonroad compared to onroad sources because there is such a diverse mix of engines in the nonroad category compared to onroad vehicles.

In terms of characterizing NRMHCs and their use, it appears that EPA has done some work in this area, and may have other resources at its disposal.

<http://www.epa.gov/nonroad/proposal/r01046.pdf>

The California Air Resources Board (CARB) is also in the process of evaluating the respective populations of 2-stroke and 4-stroke NRMHC. Cassie Lopina, 916-322-2411, is working to compile this information, which should be available shortly.

Similarly, for other spark-ignited SORE engines, the test matrix included only 4-stroke engines with the mowers, generators, and blower. A large percentage of smaller hand held and other equipment are equipped with 2-stroke engines, however. Some discussion of how prevalent 2-stroke engines are in these applications would be useful to the reader in determining how representative these data actually are.

It is worth noting that CARB is in the process of conducting speciation measurements on a small subset of NRMHCs. This data collection effort is scheduled to begin shortly, and should be considered by EPA in future updates of nonroad speciation profiles. The contact would be Sherry Zhang, 916-350-6400.

2. Is the description of analytic methods and procedures clear and detailed enough to allow the reader to develop an adequate understanding of the steps taken and the assumptions made by EPA in developing the model inputs? Are examples selected for tables and figures well chosen and do they assist the reader in understanding the intended approaches and methods?

Most of the recommendations related to this question are included above. The discussion of getting VOCs from Equation 2 in section 2.1 and getting NMHC from equation 1 in section 3.1. In section 2.3, the origin of the 17 mpg fuel economy estimate used in the conversion. Including information on the applicable studies in Table 13. Also, in the Appendix, section 2.1.3, providing more information on the Auto-Oil methods utilized. Zeroing out the acetylene values before averaging is also something that could use some consideration. In sections 4, 5, and 6, references to the original

source material where data is derived from should be added. In section 7, more information on the crankcase to exhaust ratios should be added, since this is key to understanding this section.

3. Are the methods and procedures employed technically appropriate and reasonable with respect to the relevant disciplines, including physics, chemistry, engineering, mathematics and statistics? Are you able to suggest or recommend alternate approaches that might better achieve the goal of developing accurate and representative model inputs? In making recommendations please distinguish between cases involving reasonable disagreement in adoption of methods as opposed to cases where you conclude that current methods involve specific technical errors.

Again, most of the recommendations related to this question are included above. One of the bigger ones in this category is using the onroad sources from catalyzed vehicles to make estimates for nonroad sources without catalysts, as discussed in sections 2.3 and 2.4. Also, the subtleties of the differences between the certification levels for the Tier 4 nonroad diesel engines vs. the 2007+ onroad diesel engines should be explained in section 3.1. Also, the zeroing out the acetylene values before averaging.

4. In areas where EPA has concluded that applicable data is meager or unavailable, and consequently has made assumptions to frame approaches and arrive at solutions, do you agree that the assumptions are appropriate and reasonable? If not, and you are so able, please suggest an alternative set(s) of assumptions that might lead to more reasonable or accurate model inputs while allowing a reasonable margin of environmental protection.

Overall, the estimates and assumptions made appear to be reasonable for cases where little or no data is applicable. In making assumptions, one of the aspects worth noting in the report is where estimates from catalyst equipped vehicles are utilized for nonroad engines that may not be equipped with catalysts. Again, the subtleties of the differences between the certification levels for the Tier 4 nonroad diesel engines vs. the 2007+ onroad diesel engines should be explained in the report.

In terms of additional data sets, consideration should be given to work that has been carried out in California in terms of testing of natural gas vehicles, as well as upcoming studies that will be carried out in nonroad motorcycles. A listing of references that would be worth considering for MOVES (most of which being onroad) is provided at the end of this document.

5. Are the resulting model inputs appropriate, and to the best of your knowledge and experience, reasonably consistent with physical and chemical processes involved in mobile source emissions formation and control? Are the resulting model inputs empirically consistent with the body of data and literature that has come to your attention?

The results appear to be consistent with the larger body of literature available on speciation and toxic, including data from onroad vehicles for which data are more readily available.

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Natural Gas On-road

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LPG On-road

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Diesel On-road

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Gasoline On-Road

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