



320 E Vine Drive, Suite 215, Fort Collins, CO 80524

Review of ERG report

“Estimates of the Fraction of the Fleet with High Evaporative Emissions based on the Ken Caryl Station (Denver, CO) Field Study,”

Version 6, September 25, 2010

Reviewed by: Keith Knoll, Czero Inc.

Review Date: 20 January 2012

Summary:

The subject report describes efforts by ERG and CDPHE to estimate the occurrence of high evaporative emissions vehicles in the Denver fleet. Estimation is based on a fleet study of vehicles from the Ken Caryl I/M station using direct measurements. Three methods were employed for evaporative emissions measurement: RSD, PSBED and LSBED (Remote Sensing Device, Portable Sealed Housing for Evaporative Determination, and Laboratory Sealed Housing for Evaporative Determination, respectively). Results of direct measurements (mostly PSBED) from the study group are extrapolated to the broader Ken Caryl I/M fleet based on a relationship developed between RSD and PSBED results. The analysis relating RSD measurements to SBED results appears valid and well thought out. Uncertainties were investigated and sensitivity analyses were conducted. Use of RSD appears to provide considerable promise for determining high evaporative emissions vehicles from the in-use fleet.

The limited set of vehicles (175 total) that received both RSD and PSBED measurements was used to develop a correlation between RSD readings and measured evaporative emissions. This correlation was applied to the larger set of vehicles (5830 total) that visited the Ken Caryl I/M station during the summer of 2009. In this way, an estimate was made of the percent of vehicles visiting Ken Caryl over the study period that had high evaporative emissions. This projection was well justified based on results presented in the report. Speculation was also made regarding projecting these results to the Denver-wide fleet. Limitations associated with such a broad projection were given. Specifically it was noted that the existing dataset from the Ken Caryl I/M station was limited in relevance to the Denver-wide fleet for two reasons: 1) Colorado exempts about 40% of all registered vehicles from I/M inspection based on RSD measurements and 2) the Ken Caryl I/M stations is located in an affluent section of the Denver metro area. The first caveat means that the study sample (5830 vehicles) is likely to contain a disproportionate percentage of vehicles with high emissions – either evaporative or tailpipe. As such, the study sample is likely to be biased towards those vehicles with high evaporative emissions and is therefore **not** a random representation of the Denver fleet. The second caveat means that the study sample is likely to be composed of newer, properly functioning vehicles. Again, this introduces a bias in the database preventing it from being a random representation of the Denver fleet. Speculation was also made regarding projecting these limited results to the nationwide fleet. Limitations associated with this larger projection were not discussed.

Specific comments for each section of the report regarding methodologies, analysis, narrative and conclusions are given below. Many of these comments include specific recommendations to the authors for modifications prior to report publication. None of these recommendations is considered essential; the quality of the report is generally considered acceptable as-is. However, the quality of the report could be improved with some attention to the details included below.

2.0 Background:

A cursory review of CRC's E-77 suite of studies is provided. The E-77 studies showed that vehicle evaporative emissions **do** have a significant impact on the emissions inventory. Results also suggested that to quantify this impact, it would be important to determine the rate of occurrences of "leakers" in the on-road fleet. Per the referenced California study (ref 5), high evaporative emissions vehicles make up about 1% of the gasoline fueled vehicles in the on-road fleet. The ERG report suggests that this 1% estimate may be on the low side.

ERG's prior report from the summer of 2008 (the Lipan study) is also briefly reviewed. These results are particularly relevant to the current report as they explain how RSD measurements can be used to estimate vehicle evaporative emissions.

3.0 PSLED and LSLED Hot-Soak Emissions Measurement Characteristics

This study found that PSLED (portable LED) measurements of evaporative emissions were generally higher than similar LSLED (laboratory LED) measurements.

- Analysis showed that this bias was not likely a test order issue
- Analysis also showed that this was not a time issue (with the exception of HE-3555 which was shown to have continuously increasing evap emissions with time.)
- It is assumed this was an artifact of the test apparatus.

Comparison of PSLED and LSLED evaporative emissions results generally showed that scatter of the data about the parity line was equally distributed.

Comments to the report authors:

- Elsewhere in the literature, estimates are made providing comparison of PSLED results with EPA's Tier 2 requirements for evaporative emissions.¹ It would be helpful to include that here for context.
- It would be useful to provide some further explanation regarding HE-3555 evaporative emissions behavior. Why did these emissions continue to increase with time? Was the evaporative purge system on the vehicle evaluated for proper functionality? Was any testing done to identify root cause?
- On page 3-12, the statistical analysis leading to the conclusions that "repeated LED hot-soak measurements for a vehicle would fall between 40% (=1/2.51) and 251% of the vehicle's

¹ "Evaluation of Evaporative Leaks using RSD and Inventory Implications," D. Hawkins, C. Hart, C. Fulper, J. Warila, D. Brzezinski, et. al., Presented at the 19th Annual International Emission Inventory Conference, San Antonio, TX, Sept 27-30, 2010.

average (characteristic) hot-soak value 68% of the time” should include a relevant source citation.

- The first bullet point under Summary of LSHED and PSHEd states that vehicles with low hot-soak values have PSHEd and LSHED results that “are very similar”. I think this statement is misleading and may not be correct. The similar scatter shown by the data across three orders of magnitude on a log-log plot suggests that variation at low values was indeed less than at high values. But it is not clear that the data could be considered nearly the same. This assertion requires further justification from the data analysis.
- The last paragraph in this section providing relevance to the on-road fleet requires clarification, further explanation and a review of the underlying assumptions. I believe the author is saying that because there is high scatter and a small number of samples available, the upper bound on extrapolating this data to the on-road fleet is necessarily high; higher than it would be if there were either a larger number of sample or a smaller variation in the data. If this is his message, it needs to be stated more clearly and with a more definitive confidence level. Also, is a normal distribution being assumed? If so, state it and explain why such an assumption is valid. If not, then what distribution is assumed and why?

4.0 Estimated High-PSHEd Fraction of the Ken Caryl IM Station Fleet Using EI23 Bin De-Stratification

Comments to the report authors:

- Use of the term EI23 requires definition prior to use. This term is later defined in the Appendix, however, a general definition in the body of the report would be useful and should be included. Also, it might be useful to include some basis for the use of this term – where did the name “EI23” originate? ...not essential, but would be useful.
- “Stratified” data and “de-stratified” data: It would be helpful to the reader (and still helpful to me after reading this report thoroughly) to have a better understanding of what is meant by these two terms. A layman’s explanation of these terms near the beginning of Section 4 is advised.
- Paragraph 2 of Section 4: The last sentence of this paragraph suggests that two influence factors complicate extrapolation of the Ken Caryl dataset to the Denver-wide fleet. What exactly those two reasons are, however, is not clear from the paragraph text. My interpretation is summarized in the following bullets. Text of the paragraph should more clearly support the thesis statement given at the end of the paragraph.
 1. The sample of vehicles that visit I/M stations likely has higher emissions than the fleet at-large. The Denver-wide “clean screening” program exempts about 40% of registered vehicles based on low RSD readings. Consequently, the 60% of vehicles that go to I/M stations are the higher emitting fraction of the total Denver fleet. Using this sample population for emissions projection to the Denver-side fleet will likely skew the overall population estimate. However, there is no reason to believe that high tailpipe emissions vehicles are necessarily correlated with high evaporative emissions vehicles. So the real effect of this bias is not clear.

2. The Ken Caryl I/M station is located in a higher income part of Denver. Consequently, the population of vehicles visiting this I/M station is likely to comprise newer and therefor cleaner vehicles than the Denver fleet as a whole. As far as I can tell, this bias has no mitigating factors.
- Accurate application of the Monte Carlo simulation method assumes a random distribution and a large number of samples. This paragraph should include a statement regarding the limitations of this method for analyzing the current dataset. The author does provide later in this report adequate justification that the sample population truly is random. This was well thought-out and well reported. Including some statement in this paragraph, however, would be helpful. I do not believe the author addressed the limitation of population size. This limitation should be mentioned here. Some comment regarding the potential impacts of this limitation should also be stated.
 - In Section 4.4, Table 4-6: It is not clear how the fourth and fifth columns are calculated from columns 2 and 3. This should be explained.
 - The last sentence in Section 4.4 appears to be the beginning of an incomplete paragraph. I expected further explanation or evaluation of how the EI23 bins are independent of model year groups. Did some additional text get inadvertently dropped from this section?

5.0 Estimated High-PSHED Fraction of the Denver On-Road Fleet from De-Stratifications Based on Advanced RSD Evaporative Emissions Indices

This section of the report goes on to discuss additional data that is now available for further investigation. Limitations of the additional data are also identified. For example, the PSHED data from Summer 2010 are identified as not being selected using a stratified random design. As such, these data are not suitable to the Denver-wide fleet.

This last section of the report leaves the estimation of the high-PSHED fraction of the Denver-wide fleet incomplete. No estimation is provided because the data are identified as inadequate.

This last section of the report also provides no basis for extrapolating the results obtained to an estimate of the nationwide fleet as is needed by EPA. For EPA to apply this dataset to the nationwide fleet (via MOVES), additional justification would be necessary.