16 November 2009 Preliminary Review Comments from CASAC Carbon Monoxide Review Panel on EPA's *Risk and Exposure Assessment to Support the Review of the CO Primary National Ambient Air Quality Standards: First External Review Draft (October 2009)*

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Dr. H. Christopher Frey

Review of Carbon Monoxide First Draft of Risk and Exposure Assessment

Chapters 5 and 6

Charge Question 1: Does the Panel find the summary of CO exposure and discussion of the relationship between in-vehicle and ambient concentrations to be technically sound, clearly communicated, and appropriately characterized?

Response to Charge Question 1: From a qualitative perspective, the REA reasonably characterizes the relationship between in-vehicle concentration, concentration outside the vehicle, near-roadway concentration, and area-wide concentration. It is clear that the CO concentration on the roadway is typically higher than at fixed site monitors (FSMs). It is also appropriate that the CO concentration in the vehicle is very similar to the CO concentration immediately outside the vehicle. Hence, it is appropriate to estimate that the in-vehicle CO concentration is a multiplier greater than the FSM data.

The REA could better describe the "microscale" aspects of vehicle activity and emissions that could lead to substantial variability in exposure. For example, on a portion of roadway with positive road grade, for which a significant portion of vehicles might be operating in fuel enrichment mode, the localized tailpipe emissions of CO can be much higher than elsewhere on the transportation network. Such episodes might last only a few seconds, however, and thus are of an averaging time that may not be commensurate with the available health effects data and models.

Even for longer term averages, there is likely to be substantial variability in in-vehicle exposure depending on factors such as wind speed, atmospheric stability class, vehicle traffic volume, and vehicle tailpipe emission rates.

Charge Question 2: What are the views of the Panel on the approach taken?

Response to Charge Question 2: The use of a multiplier such as 2 might be a reasonable average, but is not likely to take into account variability in onroad conditions that might lead to much higher exposures. Rather than use one number for the multiplier, a range of numbers can be used either as a sensitivity analysis or as a probabilistic analysis using a distribution.

The distribution of windspeed and direction for each FSM used in the REA should be evaluated to determine whether the monitor is upwind or downwind of the nearest major roadways. An assessment should be made as to whether the multiplier for in-vehicle to ambient proximity should be adjusted to take into account these meteorological conditions. This decision could be informed by sensitivity analysis with an air quality model such as CALINE4.

Charge Question 3: Does the Panel view the results of the exposure analyses to be technically sound, clearly communicated, and appropriately characterized?

Response to Charge Question 3: The exposure analysis does not appear to be technically sound. Consider that the last line in Chapter 6 is "staff finds the utility of this assessment for the purpose of considering theadequacy of the current standards to be limited." This statement implies that the REA is

not useful as an input to decision making regarding whether to retain or revise the NAAQS for CO. This begs the question of what can be done to improve the quality of the REA so that it is a useful basis for informing decision making.

In Section 6.4.2, the key sources of uncertainty are identified to include:

- In-vehicle CO concentration
- Commuting
- Spatial and temporal variability of CO concentration
- Historical data used for the analysis of just meeting the standard
- Activity pattern data
- Longitudinal profile data

For some of these, such as activity pattern and longitudinal profile data, and perhaps the methodology used for estimating commuting-related exposures, there is not likely to be any improvement in the next few months.

However, there is the potential for significant improvement in the characterization of spatial and temporal variability in CO concentration. There are several possibilities for improvement:

- Rather than base the analyses on only one monitor per city, use all of the monitors in the city, and restrict the geographic domain to that associated with the nearest monitor.
- Use a spatial interpolation technique to create a concentration field based on monitoring data, to enable use of multiple monitors as input to an exposure assessment
- Use air quality model output, such as from CMAQ, to characterize spatial and temporal variability in CO concentration for each urban area, taking into account some model evaluations compared to the local monitoring data
- Use CMAQ predicted CO concentrations combined with monitoring data, such as in Bayesian framework, to create a "fused" model-monitor based estimate of spatial and temporal variability in CO concentration.

The latter would be the technically most attractive approach. This would iteratively address what EPA has identified as one of the key sources of uncertainty in the analysis.

Although there may be little prospect of obtaining more measurements of in-vehicle CO concentration relative to concentration at the vehicle exterior, the use of a better CO concentration field as an input to estimating in-vehicle concentration, still using a reasonably justifiable proximity factor such as two, would nonetheless lead to some improvement in the in-vehicle concentration estimate.

The use of land-use regression models should be considered if it could improve the prediction of concentration gradients in the proximity of roadways and thus better inform estimates of in-vehicle concentration.

Regarding the analysis of just meeting the standard, there are several fairly straightforward improvements that could be made:

- Rather than focus on one scenario, try multiple scenarios
- Rather than base the assessment on an older scenario, also consider scaling from a more recent scenario (in which case one might need to scale upward rather than downward to "just meet" the standard).

Charge Question 4: What are the views of the Panel regarding the adequacy of the assessment of uncertainty and variability? To what extent have sources of uncertainty been identified and the implications for the risk characterization been addressed? To what extent has variability adequately been taken into account? Does the Panel have any recommendations for sensitivity analyses that they feel would improve this assessment?

Response to Charge Question 4:
Variability: Table 6-24 is very useful. However, there should be more discussion that helps to identify which sources of variability lead to more variation in adverse health effects compared to others. For example, does variability in activity patterns because of temperature lead to more variability in adverse effects than the population data?

Uncertainty: The document has reasonable content regarding a qualitative assessment of uncertainty. The methodology for treatment of these topics is consistent with that in other ISAs, such as for PM.

p. 6-37, line 13. The assessment endpoint is related to exposure or effect, not air quality.
Lines 16-28. Are these categories of uncertainty based on some absolute scale or relative to each other?

Table 6-25:

- knowledge base uncertainty for adjustment of air quality to simulate just meeting the standard -- it seems not very compelling that it is "largely unknown" as to how emissions level per vehicle, etc. compare between the earlier period of time and the hypothetical condition. For example, emission factors are available for vehicle technologies typical of the time period, such as in the Mobile5b emission factor model.

- Population data base – the population data are for 2000. The air quality data are from 2006. While this is not a problem per se, a reader might misinterpret that the effects estimates are based on a 2006 population. If population has increased from 2000 to 2006, then the number of incidences would appear to be underestimate relative to a 2006 population. Thus, it is important to clearly characterize that results are based on 2000 population when reporting results in tables and figures.

- Algorithm and Input Data for All other microenvironmental CO concentrations – consideration of the lag effect associated with air exchanges might delay and lower the peak indoor concentration relative to the peak outdoor concentration, but also will increase the minimum indoor CO concentration relative to the ambient concentration.

- CHD prevalence: The Coronary Heart Disease (CHD) prevalence is estimated based on gender-specific ratios applied to all age groups. Hence, there may be some uncertainty as to the accuracy of the prevalence estimates for specific age and gender groups.

The summary of uncertainty is in terms of focusing on the "direction" of uncertainty first and then considering the magnitude of uncertainty.

Page 6-41, line 12/13 (in between these) it is stated that there is “relatively less uncertainty” but intended meaning seems to be relatively ‘more’

Other comments:

Where is EPA going with this? Given that the only analyses are at the level of the current standard and “as is” air quality for two cities, does this imply that EPA is merely considering to continue the current standard? What regulatory alternatives are to be considered?

To what extent can/should there be an assessment of welfare effects related to climate change?

Dr. Beate Ritz

CO: EPA Review Risk and Exposure Assessment, Draft Comments Characterization of Exposure (Chapters 5 and 6)

Question 5. To what extent does the simplified approach taken in the document help to characterize the public health implications of the current standard.

A simplified approach is certainly justified when the data needed for a complex model is unavailable (such as a lack of enough spatially well defined CO monitoring data – note however that I do not understand why there is a 'lack of temporal variability in available ambient monitoring data as stated on page 5-24 line 24), or when modeling one of the seven steps in the conventional APEX models is not likely to impact the estimation overall; for example, since the reported ratio for indoor/outdoor CO levels is close to 1 without additional indoor sources, distinguishing between in-and outdoor activities in the population does not seem necessary. These model simplifications then are necessary and not just convenient. It would be helpful for the reader of the REA to see a table (similar to table 6-24) that lists all capacities of the APEX model for all 7 steps in one column and in a second column lists which steps were employed and what the assumptions were when doing so or why certain steps were omitted due to lack of detailed input data or because modeling was not necessary (such as when a microenvironment does not contribute to exposure differences).

Similarly, it seems that a more complex approach of estimating spatial distributions of exposure across cities might not have been possible since the density of the monitoring network and the sensitivity of instruments (with relatively high detection limits around 0.5 ppm) is not adequate to produce reliable small scale exposure surfaces for CO even in the cities with larger numbers of monitors such as LA. Moreover most monitors – even those at micro-scale levels, would not be likely to pick up the true levels for the micro-environment of greatest concern, i.e. the roadway. Thus, using one monitor that might represent proximity to roadway exposure best in both LA and Denver seems justified.

Yet, for the in-road micro-environment, it has to be recognized that these monitors are still removed from roadways and do not represent exposures in roadways and it might be questionable whether a factor of 2 to estimate in-roadway or closest proximity to roadways exposures is correct. Also exposures for residents very close to roadways maybe higher in winter during stagnant air conditions and it is not clear whether and how this type of meteorology has been taken into account. In fact, I did not understand how the weather data was being used in the APEX model. This should be clarified.

Thus overall, the simplified approach that does not model micro-environments and uses a larger radius and the monitor most reflective of roadway exposures seems justified. What seems less well justified, given the new wealth of epidemiologic data, is using only adult CVD as one of the simulated outcomes. This limits what can be taken seen as possible health effects from even low levels of CO exposure in large populations to mostly elderly individuals, when it is likely that

fetal development is affect and more than 4 million children born in the US might be a sensitive subpopulation for CO effects as well.
It is not easily understandable how the large differences in end-of-hour COHb levels for individuals above 2% for both exposure scenarios are obtained in Denver and not LA, i.e. the 26% and 56% versus 2 and 7% in Denver and 3 and 8% in LA (page 6-26); it seems that these differences depend solely on the upper percentiles of the exposure distributions that are higher in Denver than LA. How well these upper percentiles are reflecting the exposure distributions in each city ofr those in the most highly exposed micro-environments when using an ambient monitoring station to estimate personal exposures is then a question, i.e. I would like to understand better how these large differences are generated since they seem to point towards a major uncertainty in these models.

Question 6. Does the Panel have any recommendations regarding how the approach might be modified to better characterize the public health implications of the current standards, in light of the uncertainty associated with the simplified approach, the current data and time constraints on this review?

It would have been helpful if the evaluation of uncertainties had not just been done qualitatively but been accompanied by some data on how modeling specifications would change be changing the estimates. Having at least some quantitative data for one or two of the strongest and weakest factors to calibrate our judgments against would have helped understand the magnitude of their impacts and consolidated the qualitative judgments presented.

Dr. Ted Russell

In general, the CO Risk and Exposure Characterization was clear and informative, and is a good start on a more comprehensive REA. I think it begins to provide a foundation for the coming policy assessment to link potential primary standards to potential health effects. On the other hand, it was a bit disappointing.

The major disappointment had to do with how the exposure modeling was done in that it appears to be a step backwards from what was done in the last CO review, and the current analysis is biased. I would prefer taking an approach that is unbiased (or at least less needlessly biased), and individuals can interpret the results and add their individual amount of conservatism later in the process. Specifically I refer to using the highest monitor in the region, with a 20 mile impact radius, rather than a number of monitors each with a smaller area-of-influence. Using the highest monitor leads to the greatest modeled exposures, one that is likely biased high. Using multiple monitors reduces this bias. I was also disappointed by not using indoor sources in the modeling. Thus, the prior modeling was more comprehensive and informative. It would be better to provide less biased estimates and an assessment of the uncertainties. I was glad to see both the prior and current results provided. A question that came to mind is whether APEX has changed in such a way as to significantly impact the model results. If not the prior results may be more informative. If so, the degree to which model changes have impacted results should be discussed.

One problem with presenting the results as COHb levels is that it was not easy to assess the severity of the exposures with likely health outcomes, and the document was weak on this issue as well. What are the likely health ramifications of COHb levels of 1.5, 2, 3 or possibly higher? How does this interplay with COHb levels at those levels to a given fraction of the population? The discussion on pages 6-42/43 need to be more informative on this issue. This is both a risk and exposure document, and there should be more on what are the likely risks. It would be valuable to have a succinct discussion of the likely current risks from CO exposure nationally. That brings up an additional need is how the analyses for LA and Denver relate to risks and exposures nationally. The analysis done as part of the PM Risk Assessment was effective in this direction (Chapters 4 and 5 of the RA for PM… though that document would benefit from a Chapter 6 integrating them.)

I would also have appreciated examining other potential standards if changes are to be made. The current analysis suggests that there are potential exposures of concern (using COHb cutoffs of 2.0% or so), but there is no information as to how the fraction of potential exposures will respond to lower ambient CO levels reflecting tighter standards.

I also note that, like NO_2, the highest exposures to CO will likely happen in-vehicle or near to the road. If a near-road network monitoring network is to be developed, the maximum ambient levels observed will likely increase, and the in-vehicle-ambient monitoring relationships will likely change, possibly dramatically. This should be explored here. The information available in making the policy assessment should provide the needed risk and exposure characterization to

adequately inform the determination of a standard if a new network design were to be put in place.

In summary, this is a solid start. I am glad to see the exposure modeling, though it should have been more realistic (use more monitors, larger area, similar to, or preferably beyond that done in 2000). Next, if a change in standards is envisioned, this document should evaluate how a such a change might impact exposures. Without such, an important part of the foundation for future action is missing. Third, if there is going to be a change in the monitoring network,, the REA should assess the implications of such a change.

In response to the Charge Questions:

1. Air Quality Considerations
This discussion is fine.

2. Selection of Health Endpoints, etc.
2.1. Health endpoint… sound, clear and appropriate?
2.2. Does the range of benchmark reflect the ISA
2.3. Is the derivation of COHb levels sound, clean, appropriate.

3. Characterization of exposure
3.1. Relationship between in-vehicle and ambient … sound, clear and appropriate?
While the approach taken is clearly communicated and well characterized, it is somewhat over simplified. The in-vehicle and ambient concentration data relationship is variable, and it a more comprehensive treatment of this variability would be appropriate. Given the isse of using just the highest monitor for CO concentrations, there is a potential for hidden bias in that the studies upon which the factor is based typically relate in-vehicle data to a central site monitor, not the highest central site monitor. As noted in the REA, there is also the issue of vehicles having much higher CO emissions at the time of the studies mentioned than are typically present today. The potential for being near a high emitting vehicle was greater, leading to an excessively, and unrepresentatively for present conditions, high CO level in the vehicle. The biggest concern, here, however, is that the ratio of two is taken using three locations that do not represent the highest CO levels in the area.
3.2. Approach taken
As might be evident from the above, there is likely unexplored bias in the approach taken. I would prefer using methods without such bias built in.

3.3. Exposure analysis … sound, clear and appropriate?
The exposure modeling is well laid out, clear, and given the assumptions made, using an appropriate approach. However, it is disappointing to see that the prior REA was done in a way I think is better, with less built in bias, and able to better catch the distribution of exposures.
3.4. Adequacy of the assessment of uncertainty and variability? Sensitivity analysis?
The first sensitivity analysis I would conduct is to use a variety of CO monitors in the analysis, e.g., similar to what was done in 2000 as part of the prior REA. Second, I would, if possible, do a head-to-head comparison of the models used in 2000 and this time. A third sensitivity

analysis should assess how concentrations that would be measured near the road would be reflected in a simulated in-vehicle concentration.

3.5. How does the simplified approach help?

3.6. Recommendations regarding how the approach might be modified?

Additional Comments:

2-2/23 Make sure we use susceptibility and vulnerability consistently between documents. (I personally like the distinction, but recognize some do not because of the ambiguities.)

3-3: Define GFC (I did not immediately see it defined, above)

3-3/29 Replace below with "better than"

3-4/21: The number of stations belongs further up, e.g., Page 2-1 or 2-2, as part of the network description.

3-12: How much does the PRB contribute to COHb? If it is straight forward to calculate, that might be of interest.