Review of Risk and Exposure Assessment of the SO2 Primary National Ambient Air Quality Standards: First Draft

Comments to CASAC

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On behalf of API, ENSR has reviewed the first draft of the Risk and Exposure Assessment to Support the Review of the SO_2 Primary NAAQS (REA), focusing on the modeling and statistical methods that are used to estimate ambient concentrations and personal exposure to SO_2.

General Comments

In its past review of the SO_2 NAAQS (Federal Register 65, 10, 25575, 1996), EPA has noted the existence of a short-term health effects issue, but did not explicitly include a new NAAQS for either the 1-hour or 5-minute averaging period. EPA's reasons for why a short-term NAAQS was not needed was that due to the "the localized, infrequent and site-specific nature of the risk involved…short-term peak concentrations of SO_2 do not constitute the type of ubiquitous public health problem for which establishing a NAAQS would be appropriate." It is noteworthy to consider that since 1996, the existence of large, uncontrolled sources of SO_2 has decreased due to retirement of old sources, implementation of Title IV of the Clean Air Act, Best Available Retrofit Technology, and various state and federal programs that have led to substantially lower SO_2 emissions. Therefore, these localized and infrequent exposures are probably now even more unlikely as future SO_2 concentration levels drop below the current "as is" air quality levels.

A focus of the 2008 SO_2 REA is to use ambient monitoring data and dispersion modeling to estimate the frequency that short term (5-minute) average ambient concentrations and daily peak 5-minute average personal exposure concentrations exceed specified range of short-term health effects benchmarks (400 to 600 ppb) at the present time and in a hypothetical future where the highest measured annual average ambient SO_2 concentration approaches the current 24-hour (140 ppb) and annual average NAAQS (30 ppb).

The preliminary results of the first draft REA supports the notion stated in previous SO_2 NAAQS reviews that existing primary NAAQS are generally protective of health effects possible associated with short-term excursions. In reviewing the analysis of measurement data and the modeling approach described in the REA, ENSR has identified a number of technical issues that could affect the findings and conclusions of both the ambient air quality and personal exposure assessment.

A key finding of our review is that the estimation of concentration fluctuations over time periods as short as five minutes from measurements or modeling, both of which have a standard resolution of 1-hour, presents a technical challenge and is subject to a substantial degree of uncertainty. The statistical methods applied in the REA to estimate the Peak to Mean Ratios (PMR, maximum 5-minute average concentration in a given hour divided by the corresponding hourly concentration) characterize this variability, but are not sufficiently refined for site-specific assessments. This limitation is illustrated in the REA cases where the computed PMRs either substantially overestimate or underestimate the monitored excursions of the suggested 5-minute health effects benchmarks. Given these limitations in the ability of the statistical method used in the REA to estimate peak 5-minute concentrations, it is suggested that methods to further refine the PMRs be sought, perhaps by more directly accounting for the variables that are known to affect concentration fluctuations. The comparison of extrapolated peak 5-minute concentrations also does not consider the intra-hourly distribution or frequency of elevated 5-minute concentrations that could be important in the determination of health effects.

Another finding is that the veracity of assumptions which are inherent in the roll-up method, used in the REA to evaluate peak 5-minute concentrations when monitored or modeled concentrations “just meet” the existing 24-hour and annual standards, should also be more closely examined. For example, the method assumes that the distribution of concentrations over all averaging times change by the same fraction, which implies that all types of sources increase by the same percentage.

A statistical analysis of “as is” air quality in 20 Missouri counties, which represent a region of the U.S. with relatively high SO_2 concentrations (Table 6-11 and 6-13), indicates that excursions of the 400 ppb, the low-end 5-minute health effects benchmark, are infrequent. In the most affected county, the number of excursions average less than once per day and 32 times per year. When the ambient concentrations are rolled-up to the current NAAQS, the projected frequency of excursions increases to a mean of once per day and 142 times per year. Likewise, the exposure assessment for Missouri indicates that the “as is” air quality (Table 7-14) exposes exercising asthmatics to no more than a single 5-minute concentrations above the 400 ppb level per year. Even when the ambient concentrations are rolled-up to the current NAAQS (Table 7-16), 11 exercising asthmatics would be exposed to 400 ppb 5-minute concentrations more than once per year. Based on these projections, it seems unlikely that the health risk from short-term exposure, which will be evaluated in Section 9 of the second draft REA, will indicate a an existing health concern that warrants instituting a short-term NAAQS for SO_2.

Specific Comments

Statistical Method for Estimating 5-minute Maximum Concentrations (6.2.3)

A sizable database of coincidentally measured hourly peak 5-minute concentrations and 1-hour average SO_2 concentrations were used to derive a statistical method to model the hourly 5-minute peak based on hourly concentrations. PMR’s were determined to be quite variable from site to site and from hour to hour. The statistical parameter that reflects site-to-site differences was the coefficient of variation, COV, which is the standard deviation of the hourly measurements divided by the average. A low COV is indicative of an area with well-distributed sources and a high COV indicates that a small number of sources dominate. The hour-to-hour variability in the PMR is somewhat reflected in the magnitude of the hourly concentration. As shown in Figure 6-4, even if the data is categorized by COV and magnitude of 1-hour concentrations, there is still a large variability in the PMRs, especially for areas with high COV and moderate hourly concentrations. For this reason, rather than using deterministic values, the REA applies the mean PMR determined by the average of 20 random samples which are selected from the probability distributions of the measured PMRs.

This randomized approach inevitably results in cases where the actual PMR is overestimated or underestimated, possibly by substantial margins. Page 45 of the REA identifies that a monitor dominated by a local source where the number of 5-minute excursions of the benchmark is underestimated by 45%. At the other extreme, page 46 of the REA identifies a case where sources were more evenly distributed where the statistical 5-minute extrapolation indicated over 100 5-minute benchmark excursions at a monitoring location where no excursions actually occurred. These two examples indicate the desirability of a PMR modeling method that more directly accounts for the source-related factors that affect intermittency of ambient SO_2 concentrations. It may be possible to select several monitoring sites with 5-minute measurements located in areas where SO_2 sources are well characterized to examine in more detail the relationship between PMR values and source and source-receptor parameters such as release height, distance and geographical distribution. These relationships could be used to provide more robust PMR estimates that can be used in modeling exposures. For instance, if a receptor is known to be located in an area dominated by a few point sources or distributed area sources, a correction factor could be applied to the computer PMR or perhaps rather than using the average of the 20 PMR model simulations, the refinement may indicate that a higher or lower percentile value of the 20 simulations should be applied.

It is also known that in addition to source characteristics and source-receptor relationships, dispersion conditions are also govern the PMR. For instance, a common deterministic PMR modeling method for sub-hourly concentrations is to apply factors based the ratio of averaging periods raised to a power, where the power varies according to atmospheric stability category. Coincident hourly SO_2 and meteorological data could be used to determine if by segregating the hours by stability class (or as a simple surrogate, day versus night) improves PMR model performance.

We suggest that the REA discuss the effect of these factors in more detail and investigate which of these could be incorporated into the statistical modeling to improve the predictability and improve the reliability of the 5-minute concentration estimates.

Ambient Air Quality Adjusted to "Just Meet" the Current Standard (6.4.3, 7.9.3)

This method assumes that increases and decreases in annual SO_2 concentrations will be proportionately reflected in the highest measured annual concentrations, 24-hour concentrations and 1-hour concentrations (5 – minute concentrations are, in turn, modeled based on the 1 hour concentrations). In order for this to be valid, the monitor needs to be at the location of maximum impact from the collection of sources affecting air quality and hourly emissions from all of the sources affecting a receptor would need to change by the same proportion. Otherwise a roll-up of emissions would cause excursions of the NAAQS at locations closer to the sources.

In both the ambient air quality analysis (Section 6) and the exposure analysis (Section 7), a roll-up method is used by EPA to extrapolate monitored or modeled conditions, respectively, to hypothetical future conditions where either the 24-hour average or annual average NAAQS for SO_2 is "just met". For the ambient analysis, the ratio of the second-high monitored 24-hour concentration and annual average concentration are compared to their respective standards to determine which is more limiting. The corresponding ratios are then used to scale-up the maximum 1-hour concentration, which are then used to model the corresponding 5-minute average concentration.

For the exposure assessment, the modeled ambient concentrations rather than the measured concentrations are used and the adjustments are then applied to roll-down the acute health effects benchmarks. The methods used in the REA of applying roll-up to the ambient measurements and roll-down to the benchmarks for the modeled concentrations are not equivalent because the PMRs applied in the REA are dependent on the 1-hour SO_2 concentration. This relationship between the PMR and 1-hour SO_2 concentration is accounted for in the ambient assessment but not in the exposure assessment. The roll-up procedure should be more clearly discussed in the REA and the implications should be discussed.

Characterization of Ambient Hourly Air quality Data Using AERMOD (7.4)

AERMOD and the supporting emissions meteorological data are not capable of directly estimating 5-minute average concentrations. The AERMOD results were therefore extrapolated to peak 5-minute averages using the PMR model. AERMOD was applied with established emission bases to estimate ambient 1-hour, 24-hour and annual average concentrations at selected receptor areas accounting for facilities within 20 km that have emissions exceeding 1000 tons of SO_2 per year and within each subject facility, all sources with emissions exceeding 1 ton per year. It would be appropriate for the REA to provide a more detailed rationale for the range of distances and emission rates considered. The performance of the model in estimating 1-hour concentrations is displayed by comparing the frequency distribution of modeled and measured concentrations in Figures 7-3 and 7-4. A comparison is made between model (census block centroid) receptors within 4 km of the monitors, rather than placing receptors at each monitor location. Although the comparison indicates that for concentration above about 5 ppb, that the maximum and minimum AERMOD concentrations bracket the monitored concentrations, a separate modeling analysis for a receptor placed at each monitor would provide a more direct indication of model performance.

Conclusions

The first draft of the REA for SO_2 has noted substantial uncertainties in measuring and modeling short-term ambient concentrations, estimating inhalation exposure and relating exposure to health effects. Due to the extent and underlying reasons of these uncertainties, the analysis in the REA is insufficiently robust for EPA to establish a 5-minute, NAAQS for SO_2. Some of the factors that contribute to this conclusion are:

- Estimation of peak 5-minute concentrations is highly uncertain due to parameters that are known to govern short term fluctuations, but which are not addressed in the PMR model applied in the REA. Refinements to the methodology to estimate 5-minute concentrations should be investigated prior to conducting the health assessment.
- Current dispersion models are not designed and emissions estimation methods as well as meteorological data are not available to accurately simulate 5-minute concentration fluctuations. Development and validation of suitable modeling tools would be a significant undertaking and unlikely to be accomplished in the near future.
- Methods used in the REA to roll-up measurement and modeling data to “just meet” NAAQS are inherently approximate and are based on the unfounded assumption that the relative contributions of emission sources are static.