

**Preliminary Comments from Members of the CASAC Augmented Sulfur Oxides Panel on EPA’s Integrated Review Plan for the Primary National Ambient Air Quality Standard for Sulfur Dioxide (External Review Draft)**

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## Mr. George A. Allen

Overall organization and clarity: To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the primary SO<sub>2</sub> NAAQS and the key scientific and policy issues that will guide the review? To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?

The draft plan is well organized and clearly describes the review plan. A very useful description of decisions in the last review and the rationales for them are presented in Chapter 3, especially the reasoning behind the new 1-hour standard in the context of its ability to reduce 5-minute exposures of concern to SO<sub>2</sub>.

Introduction (Chapter 1) and Schedule (Chapter 2): To what extent does the Panel find that Chapters 1 and 2 clearly communicate the NAAQS legislative requirements, summarize the steps in the review process, summarize the history of the SO<sub>2</sub> NAAQS, and present the anticipated schedule for the current review?

These chapters are a good summary of the process and history of the SO<sub>2</sub> NAAQS. The schedule presented in Chapter 2 is reasonable, with the uncertainty regarding an update to the REA appropriately noted. There is recent precedent for not issuing a REA document as part of a NAAQS review process; for the recent review of the Pb NAAQS, CASAC agreed with EPA staff that an update to the Pb REA was not necessary given the lack of significant new studies since the last review and REA.

Ambient Air Monitoring (Chapter 6): To what extent does Chapter 6 clearly and appropriately communicate, for the purposes of this plan, the key aspects of measurement methods and surveillance network requirements for the SO<sub>2</sub> NAAQS?

This chapter is a very brief summary of monitoring methods and monitoring network requirements. Section 6.1 properly notes that there are no new technologies that might be relevant for measurement of SO<sub>2</sub> in routine regulatory monitoring networks. The recent requirement for reporting 5-minute maximum hourly concentrations is noted; this will allow analysis of the relationship between these very short term exposures and the 1-hour concentrations that the revised NAAQS is based on.

Section 6.2 briefly notes the options unique to SO<sub>2</sub> for using monitoring or modeling to demonstrate compliance with the NAAQS (p. 6-2, l. 13-22). The discussion of modeling vs. monitoring has been ongoing between EPA and monitoring agencies since the last revision to the SO<sub>2</sub> NAAQS in 2010, with the next step in the process being a proposed “Data Requirements Rule” due from EPA this May (2014):

<http://yosemite.epa.gov/opei/rulegate.nsf/byRIN/2060-AR19?opendocument>

Because of this expected rule-making and the related finalization of Technical Assistance Documents (TADS) for use of SO<sub>2</sub> monitoring and modeling in an agency's network design, it remains unclear at this time to what extent the existing SO<sub>2</sub> monitoring network may be adequate for assessing compliance with the revised 1-h SO<sub>2</sub> NAAQS. The upcoming SO<sub>2</sub> NAAQS documents need to include a substantial discussion of this issue as it relates to the monitoring network, with updates as appropriate as new rules and TADS are issued by EPA.

## Dr. John Balmes

**Chapter 3, Key Policy Relevant Issues** : Building on key considerations and issues addressed in the last review, Chapter 3 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?

After reading the draft Integrated Review Plan for the Primary National Ambient Air Quality Standard for Sulfur Dioxide, I find the policy-relevant questions listed in Chapter 3 to appropriately and thoroughly cover the key issues for the planned review of the NAAQS. No additional issue beyond those covered by the listed questions comes to mind at this point.

## Dr. James Boylan

**Overall organization and clarity:** To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the primary SO<sub>2</sub> NAAQS and the key scientific and policy issues that will guide the review? To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?

**RESPONSE:** The IRP does a good job of communicating the plan for the current review of the primary SO<sub>2</sub> NAAQS and the key scientific and policy issues that will guide the review. Most of the decisions made in the last review were clearly described and justified. However, there was no justification presented on why a 1-hour standard was chosen over a 3-hour standard.

**Introduction (Chapter 1) and Schedule (Chapter 2):** To what extent does the Panel find that Chapters 1 and 2 clearly communicate the NAAQS legislative requirements, summarize the steps in the review process, summarize the history of the SO<sub>2</sub> NAAQS, and present the anticipated schedule for the current review?

**RESPONSE:** These items were clearly communicated.

**Key Policy Relevant Issues (Chapter 3):** Building on key considerations and issues addressed in the last review, Chapter 3 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?

**RESPONSE:** The policy-relevant questions were appropriate. On page 3-7, it is not clear what is meant by “With respect to a 5-minute standard, there were concerns about standard stability”. In addition, it is not clear why “...concerns related to the number of monitors needed and the placement of such monitors given the temporal and spatial heterogeneity of 5-minute SO<sub>2</sub> concentrations” would be any different than the concerns related to measurements of 1-hour SO<sub>2</sub> concentrations. I have no additional issues to be considered.

**Science Assessment (Chapter 4):** Chapter 4 describes the plan for the Integrated Science Assessment (ISA), which will critically evaluate and integrate the scientific evidence on health effects due to sulfur oxides in the ambient air. To what extent does Chapter 4 clearly and adequately describe the scope, approach, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.

**RESPONSE:** This chapter clearly outlined the scope, approach, specific issues to be considered, and organization of the ISA. On page 4-11, the IRP states “What do monitoring, satellite data, and dispersion modeling results indicate regarding spatial patterns on neighborhood, urban, regional, and national scales?” Photochemical modeling should be added to the list since they can be used at urban, regional, and national scales. I have no additional issues to be considered.

***Quantitative Risk and Exposure Assessment (Chapter 5):*** Chapter 5 summarizes the key risk and exposure analyses from the last review, including associated uncertainties, and discusses our planned approach to considering the potential for additional analyses in the current review. To what extent does Chapter 5 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review? To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?

**RESPONSE:** Chapter 5 clearly and adequately describes the scope and specific issues to be considered in developing the REA. I have no additional issues to be considered.

***Ambient Air Monitoring (Chapter 6):*** To what extent does Chapter 6 clearly and appropriately communicate, for the purposes of this plan, the key aspects of measurement methods and surveillance network requirements for the SO<sub>2</sub> NAAQS?

**RESPONSE:** Chapter 6 gives a brief overview of the measurement methods and surveillance network requirements for the SO<sub>2</sub> NAAQS. It would be good for the IRP to include the PWEI (Emissions x Population/1,000,000) criteria that were used previously to calculate the minimum number of SO<sub>2</sub> monitors in each CBSA: PWEI > 1,000,000 (minimum of 3 monitors), PWEI between 10,000 - 1,000,000 (minimum of 2 monitors), PWEI between 5,000 - 10,000 (minimum of 1 monitor), and PWEI < 5,000 (no monitors). In addition, EPA should consider alternate population-emission metrics since the current approach unfairly targets CBSAs that cover large geographic areas. Instead, EPA should consider normalizing the population and emissions in the PWEI calculation by the geographic area (Emissions/Area x Population/Area). In addition, since the highest SO<sub>2</sub> impacts from large SO<sub>2</sub> sources are generally limited to a 10-km radius, EPA might consider a PWEI calculation based on actual SO<sub>2</sub> emissions from individual large point sources and the population within a 10-km radius around the source. The IRP states that dispersion modeling can be used in lieu of monitoring to potentially reduce the necessary size and distribution of a compliance monitoring network. However, current dispersion models do not always perform well and can show large biases (both positive and negative). If there is no local SO<sub>2</sub> monitoring data available to verify the model outputs, then the modeling results may be called into question.

***Policy Assessment and Rulemaking (Chapter 7):*** To what extent does Chapter 7 clearly summarize the general process for the policy assessment and rulemaking phase of this review?

**RESPONSE:** Chapter 7 does a good job of summarizing the policy assessment and rulemaking process.

## Dr. Aaron Cohen

### ***Overall Organization and Clarity***

I found the draft IRP was, for the most, part clearly written and communicated well the plan for the current review. I learned much from reading it regarding EPA's current process for NAAQS reviews in general and about the evolution of the SO<sub>x</sub> standard. The decisions taken in the last review and the rationales for them were, for the most part, well-described.

Specific suggestions/comments:

- I would have appreciated more detail on the rationale for CASAC's decision with regard to long-term exposure summarized, too briefly in my view, on page 3-10, lines 14-18.

### ***Introduction (Chapter 1) and Schedule (Chapter 2)***

I thought the chapters communicated clearly the NAAQS legislative requirements and the review process, the evolution of the SO<sub>x</sub> NAAQS, and, for the most part, the schedule for the current review.

Specific suggestions/comments:

- Provide an explicit definition of "criteria" as opposed to "standard" (page 1-1, lines 24-25)
- The information in Table 2.1 (page 2-2) would be better presented as a time-line, especially as regards the temporal overlap between the ISA and REA processes discussed on page 1-6.

### ***Key Policy Relevant Issues (Chapter 3)***

The questions proposed by EPA appear to cover the relevant issues both with regard to uncertainties re. the current 1-hour standard and the much broader set of questions regarding exposure to and health effects of SO<sub>x</sub> about which new evidence may have emerged since 2010.

### ***Science Assessment (Chapter 4):***

Chapter 4 provides, for the most part, a clear and comprehensive description of the scope, approach, specific issues to be considered, and organization of the ISA.

Specific suggestions/comments:

- Page 4-2, line 32: should read Figure 4.1 not Figure 3.1.
- Page 4-5, lines 8-9: are the EPA studies peer-reviewed?
- Page 4-5, lines 14-15: suggest changing "whether the results are..." to "...but not the study results."

- Page 4-6, lines 9-10: Suggest deleting from “,which refers...population,” Substitute “,which refers to inaccuracies in the characterization of the exposures of study participants,”
- Page 4-8, line 26: the “five-level hierarchy” of evidence used by EPA is described on page 4-16, lines 19-24. Suggest moving to Page 4-8.
- Page 4-9, lines 3-5: Said earlier, repetitive.
- Page 4-9, line 8: suggest “exposure response” rather than “concentration-response.”
- Page 4-9, Section 4.3.5: Not really sure from this description what the QMP really entails. Lines 28-32 appear to describe the QA/QC of USEPA intra-mural research but a link to the actual QMP processes might help here.
- Page 4-11, lines 6-10: If no SO<sub>x</sub>, other than SO<sub>2</sub> are present that are “significant for human exposure” then this begs the questions on lines 11-14 on page 3-14 and lines 24-26 on page 3-15.
- Pages 4-16/17, lines 34/1: Re. “...some factors are (e.g., age) interconnected and may influence risk through multiple avenues.” What is age interconnected with and what avenues?

### ***Quantitative Risk and Exposure Assessment (Chapter 5)***

Chapter 5 provides a clear description of the REA from the 2010 review and describes clearly and completely the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review. The focus is largely on reducing the uncertainties in the current 1-hour NAAQS (see Table 5-2) but EPA’s general formulation is sufficiently broad to allow for changes in the scope of the REA that might be warranted by the new ISA.

### ***Ambient Air Monitoring (Chapter 6)***

Chapter 6 is generally clear, and its main conclusion appears to be that there are, if anything, more SO<sub>2</sub> monitors than are either required or, perhaps, needed.

### ***Policy Assessment and Rulemaking (Chapter 7)***

Chapter 7 is very clear and succinct.

## Dr. Alison Cullen

### **Comments on Chapter 5 (Quantitative Risk and Exposure Assessments) with the charge questions:**

1. To what extent does Chapter 5 clearly and adequately describe the scope and specific issues including identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review?
2. To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analysis in the current review?

Chapter 5 is well written and clearly describes the scope and specific issues and uncertainties. The previous REA supported the revision to a 1 hour standard at 75 ppb and identified uncertainties for future consideration. With the current review, there is a chance to consider what could be changed, updated or improved. In particular there is an opportunity to do additional analysis, with new data resulting from the requirement after the last review, that states must report either the highest 5-minute concentration for each hour of the day, or all twelve 5-minute concentrations for each hour of the day. Specifically, for the last review there were 5 minute concentrations from 98 monitors available, and at this time data from many additional monitors are in hand.

#### **5.2.1 Ambient Air Quality Characterization**

With the augmented dataset it is timely to think about 5 minute values, to establish whether the data can be used to give insight into relationships between these and the 1 hour and other averaging times.

With the additional data there is an opportunity to develop a new model to estimate 5 minute concentrations from hourly concentrations. EPA suggests incorporating additional characteristics with these data such as proximity to emission sources, and suggests the exploration of relationships between the 5 minute peaks and the longer averaging times (1 hour to 24 hour). The review could be more clear on the point - is anything unusual about the years from 2010-2012 (nationwide) that would lead one to worry about bias in the data relative to the longer term dataset beginning in 2003? Also, regarding the location of the additional monitors for which new data are now in hand – where are these? from targeted areas? all over US?

#### **5.2.2 Exposure Assessment**

Great list of considerations that may influence exposures appears in the bullets on page 5-8, both from the concentration angle and from the human angle.

Why and how were the two study locations for the exposure modeling selected? They seem similar for climate and possibly for demographics - Greene County Missouri and 3 counties in St Louis Metro Area.

Regarding the exposure-response relationships that were derived from human studies and used in conjunction with the outputs from the exposure modeling to estimate health impacts: in the last review EPA stated that 5 minute peaks “will likely cause adverse health impacts in a subset of asthmatics”, thus with the 5 minute concentration data now available, another look is warranted to gauge the extent to which this might be expected. Is there a possibility with any newly available epidemiological studies to use metagenomic data to identify sensitive groups via genetic markers and/or to get an estimate of the relative risk of health effects associated with various genetic markers?

### **Section 5.2.3 Risk Assessment**

This section is clear and comprehensive. Regarding the question as to whether there are any possible newly identified at-risk study groups, I refer to the previous point above. Aside from metagenomic approaches what other means should be used to identify such potential groups? A review of epidemiological evidence is certainly one component, to see what studies might now be available for the QRA.

### **Table 5-2 (uncertainties and potential use of new information for reducing them)**

Regarding exposure assessment and representativeness of the two study areas, it is stated that they have two differing emissions and population density profiles. Do they have similar climates? Similar demographics? With the availability of recently collected 5-minute ambient monitor concentrations and the idea that exposure estimates could be developed for other study areas – it is interesting to consider the impact of past selection of study areas. This can help inform the approach to selection moving forward.

**5.2.4 Uncertainty and variability** – this section tackles the question - what were the most significant sources of uncertainty and variability in the prior analysis, and will these be informed by additional data and studies available this time? The WHO 2008 approach will keep this current review consistent with past review. The additional 5 minute concentration data of recent years could help to address continuing issues such as related to analysis of uncertainty due to the estimation of 5 minute maximum SO<sub>2</sub> values from longer averaging time data. Might also help with an assessment of how representative the two study locations are of the US as a whole, and may also inform efforts to add exposure estimates for other study areas. Finally the relationship of 5 minute peaks to other averaging times will be relevant to considerations of responses in asthmatics of various levels of severity.

### **Other Items/Questions/Notes**

The term sRaw appears, but is not defined in the glossary – it would be helpful to define in the text and/or glossary, i.e., specific resistance of airways.

It would be useful to say more about what the proportional approach entails (on page 5-4), just a sentence or two would help, although a citation to the last REA is given so perhaps that is sufficient for directing readers.

Top bullet on page 5-6 needs to be clarified, there may be a phrase missing(?).

Sixth bullet under section 5.1.2 regarding the shape of exposure-response relationships for asthmatics with more severe disease than those tested in chamber studies, is there any information about this issue for other air pollutants that could shed light here?

Eighth bullet under section 5.1.2 regarding uncertainty about how well the two modeled areas in Missouri are representative of other locations in the US - is there more information somewhere on the climate and demographic differences between these two locations, or between Missouri and the rest of the country?

## Dr. Delbert Eatough

### Preliminary Comments on IRP Chapter 4: Science Assessment

Charge Question: Chapter 4 describes the plan for the Integrated Science Assessment (ISA), which will critically evaluate and integrate the scientific evidence on health effects due to sulfur oxides in the ambient air. To what extent does Chapter 4 clearly and adequately describe the scope, approach, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.

The overall outline for development of the Integrated Science Assessment for Sulfur Oxides is reasonable and well thought out. The outline given in Appendix A for the intended structure of the Assessment is clear and detailed.

I do have a number of suggestions for EPA consideration as the document is developed.”

#### Nomenclature:

The NAAQS under review is that for SO<sub>2</sub>. The primary health effect which has justified the creation of this NAAQS is the morbidity effect on asthmatics exposed to ambient SO<sub>2</sub>, with the casual relationship between exposure and morbidity effects based on both human exposure and epidemiological studies. SO<sub>x</sub> (sulfur oxides in the atmosphere) refer to SO<sub>2</sub> plus all the products of SO<sub>2</sub> chemistry in the atmosphere. These include gas phase SO<sub>3</sub> (which may also be emitted from sources). As pointed out in the assessment plan and in the assessment for the 2010 standard review, SO<sub>3</sub>(g) will quickly react with water in the atmosphere to form sulfuric acid, which is both hygroscopic and reactive with ammonia. This results in the facile conversion of SO<sub>3</sub> to sulfuric acid aerosol and subsequently to the rapid formation of sulfate and acid sulfate aerosols. Thus the gas phase SO<sub>3</sub> species is not important with respect to health effects. Furthermore, both sulfuric acid aerosol and ammonium sulfate aerosols, whether acidic or completely neutralized, have been shown to not have a significant effect on asthmatics at concentrations comparable to those for which observable SO<sub>2</sub> effects are seen. This is all well outlined in the previous assessment. I find it strange and awkward, therefore, that reference through this (and other chapters) put the emphasis in both the chapter outline and throughout the text on SO<sub>x</sub>. I think the intent of the review would be more clear if the reference was generally to only SO<sub>2</sub>, which other sulfur oxides being mentioned where needed or appropriate.

#### Relationship to Sources:

A potentially enlightening exercise might be to examine if any relationship exists between the results of epidemiological studies and the source of SO<sub>2</sub> for a given epidemiological study. I

suggest this because it might enlighten whether particulate S(IV) (e.g. absorbed SO<sub>2</sub>) might be important in exacerbation of asthma. This suggestion is based on the early laboratory studies of Amdur (1971) and Alarie (1973) which indicated that exposure to both SO<sub>2</sub> and metal oxides present in smelter emissions resulted in an enhanced animal response and that sulfite aerosols were irritating. Postulating that the work of Amdur might reflect the presence of metal sulfite species in the aerosols studied, we conducted studies on S(IV) associated with ambient aerosols. This work demonstrated that stable transition metal ion - sulfite species existed in aerosols associated with smelter emissions (Smith 1976, Eatough 1979, Eatough 1980) and could be formed in aging smelter plumes (Eatough 1981, Eatough 1982). The sulfite species were present at from 10 to 30% the sulfate species in these smelter associated aerosols. The sulfite species were less important in urban or coal-fired power plant plumes (Eatough 1978). We also demonstrated that stable Fe(III) -S(IV) aerosols could be routinely generated in the laboratory (Hilton 1979).

If these S(IV) containing aerosols identified in the above reviewed research account for the enhanced effect of SO<sub>2</sub> in the presence of transition metal containing aerosols in animal exposure studies, then this class of compounds may be important in the interpretation of the morbidity effects associated with exposure to pollution from refinery sources. A careful review of pertinent epidemiological literature may inform this postulate.

The current set of counties which are nonattainment with respect to the current NAAQS will probably not provide the needed information. A review of nonattainment counties with populations near or over 100,000 show that with two exceptions, the SO<sub>2</sub> exposures are dominated by emissions from coal-fired power plants, where aerosol S(IV) species are less important. The two exceptions are Jefferson County, MO where about 30% of the SO<sub>2</sub> emissions currently are from the Herculaneum Lead Smelter, with the remainder being from coal-fired power plants and the Steubenville, Weirton region in eastern Ohio and western Pennsylvania, where emission from the Weirton Steel are likewise, a minor portion of the SO<sub>2</sub> emissions in the immediate area, with coal fired power plants being more important. These two locations would only stand out from the other nonattainment areas if the morbidity influence of aerosol S(IV) species was much greater than that associated with coal fired power plant aerosol emissions and with SO<sub>2</sub> itself. In addition to being a nonattainment area, Jefferson County, MO was also highlighted in the September 2008 Integrated Science Assessment for Sulfur Oxides, but no epidemiological discussion associated with this nonattainment area (part of the St. Louis MO MSA).

Probably a more fruitful set of data to evaluate the relative importance of aerosol S(IV) species associated with smelter emissions would involve past epidemiological studies from about two to three decades ago when smelter emissions were much more significant, for example from the TX smelters in El Paso (ASARCO Cu smelter, closed in 1999), and Corpus Christi (ASARCO Pb smelter, closed in 1985), AZ smelters (ASARCO Cu smelter in Hayden, currently operating and Phelps Dodge Cu smelter in Douglas, closed in 1987), from the Kennecott Cu smelter in Magna, UT prior to construction of the tall stack, from the Tacoma WA smelter (American Smelting and

Refining (Cu smelter specializing in high As ore refining, closed in 1985), or the smelters in Montana (ASARCO Pb smelter in East Helena, closed in 2001, Anaconda Cu smelter in Anaconda, closed in 1981) and Idaho (Bunker Hill Pb smelter in Kellogg, closed in 1982). I know that several epidemiological studies were conducted at these locations, but I am not familiar with the results of these studies with respect to Asthma exacerbation. I recommend that EPA look at this older data to see if an estimate of the relative potency of SO<sub>2</sub> and smelter associated aerosol S(IV) species can be determined. There will not be data on the concentrations of S(IV) in the aerosols emitted from these sources, so total particulate exposure would need to be used as a surrogate. The importance of elucidating the effect of these exposures is correctly alluded to on Page 4-12, Line 11.

### **Consistency of Results**

On Page 4.7 there is a brief discussion about pooling high quality epidemiological studies and examining consistency of results. I would like to suggest that lack of consistency of results in otherwise high quality epidemiological data may well be an indicator of the need to examine potential sources and atmospheric chemistry of SO<sub>2</sub> closely to see if the apparently outlier study actually points to new insights on toxicological species. This, of course, is the main point of my discussion in the preceding section of my comments.

### **Relationship to Sulfate**

On Page 4-11, line 30 and Page 4-12, line 32 a bullet is given on the importance of understanding the relationships between SO<sub>x</sub> concentrations (I believe SO<sub>2</sub> may be what is really meant) and other components of particulate material such as sulfate as well as other gaseous pollutants. While this is a worthwhile exercise, I encourage you to include emissions source variability in that assessment.

### **Minor Points**

Page 4.1, line 15. There is no section 3.4.

Page 4.4, line 8. Section 4.3.2. should be the reference.

Page 4.6, line 14. Reference is not in reference list.

### **Preliminary Comments on IRP Chapter 3: Key Policy-Relevant Issues**

Charge Question: Building on key considerations and issues addressed in the last review, Chapter 3 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?

The material under the first bullet, and the first subbullet on page 3-14 (line 11) underscores my uncertainty of the guiding hypothesis in the review of the SO<sub>2</sub> standard. It seems to me that the last review of the standard resulted in identification of a link between SO<sub>2</sub> exposure and the exacerbation of asthma as the underlining scientific evidence on which the SO<sub>2</sub> standard was based. Yet this statement (and related points throughout the document) seem to imply that all SO<sub>x</sub>, including both gas and particulate associated species is the key indicator. There seems to me to be an inconsistency with regard to this point that is somewhat confusing.

### **Preliminary Comments on IRP Chapter 6: Ambient Air Monitoring**

Charge Question: To what extent does Chapter 6 clearly and appropriately communicate, for the purposes of this plan, the key aspects of measurement methods and surveillance network requirements for the SO<sub>2</sub> NAAQS?

My comment here is really a repeat of the comment above. The charge question seems clear and correctly framed. Yet the first paragraph states (bold emphasis mine) “This chapter describes plans considering these aspects of the ambient air monitoring program for **sulfur oxides** which includes the indicator SO<sub>2</sub>.” And line 17 of the first page states “SO<sub>2</sub> is the indicator for the **sulfur oxides** NAAQS, ...” And then, as appropriate, only SO<sub>2</sub> sampling is discussed.

I would suggest that EPA should be more consistent in stating this is a review of the SO<sub>2</sub> standard.

The suggestion inherent in many sections of this chapter that equal weight will be given to understanding other components, such as sulfate, cannot, of course be met. Only the SO<sub>2</sub> monitoring program will allow evaluation of short term (5-10 minutes) exposures, which appear to me to be a very important part of new data which will be examined in the current review.

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## Dr. William Griffith

### Comments on Chapter 5

Over all I found the document to be well thought out and important issues identified for the new IRP for the PNAAQS for SO<sub>2</sub>. In particular Chapter 5 clearly outlined a number of important issues, questions and potential improvements. In particular I found Table 5-2 very helpful in understanding what is being proposed.

The discussion in Chapter 5 does a good job of describing the scope and uncertainties based upon the previous analyses of SO<sub>2</sub>. Also in many places it describes the potential for the scope and uncertainties to change based upon the results of the ISA. This may change what is viewed as the most important uncertainties and could alter the scope of the review. I do have questions about several aspects of the process that were not obvious to me in the External Review Draft that I outline below..

I read the Draft as describing a process of developing the ISA and then implementing the results of the ISA into the exposure and risk assessment models described in Chapter 5, the REAs. To what extent is there a review of the REAs by the staff developing the ISAs to determine if what they understood from the scientific studies is being appropriately implemented in the REAs. The staff developing the ISA will have the most sophisticated understanding of the scientific studies. Their review could potentially catch any misinterpretation of their summaries of the selected studies in the REAs. Because of the complexity of the undertaking staff with different types of expertise are involved in each part of the process and may have different understandings of the same terms and concepts. Also, would such a review of the REAs be documented so that the process of review would be transparent to others outside of the staff?

I did not see in Chapter 5 a process of review of the recent literature on the methods used for implementing the REAs. There should be a process similar to that used for developing the ISA. While this literature may be much more limited compared to the ISA it might enhance the credibility and transparency of the REAs by demonstrating that a process of review for alternative approaches was considered and a willingness to communicate details about that approach. I have seen recent EPA documents describing how to conduct these types of reviews for IRIS that might be adapted here.

Other minor comments:

P5.1 lines 31-32 “with lower associated uncertainties”—sometimes new methods may identify higher uncertainties because of misunderstanding in prior analyses of how to properly estimate the uncertainties.

P5.6 lines 25-26. If the ISA identifies that it is important to consider other pollutants what would be the process for implementing exposure models to characterize the other pollutants, or will some other alternate approach be used?

P5.9 line 1. Will the methods used in APEX be reviewed in light of the ISA?

P5.13 lines 8-13. Will the literature be reviewed for other additional approaches to be considered?

## Dr. Steven Hanna

### **Preliminary written comments, prepared for CASAC as part of preparation for conference call on 22 April 2014.**

I was asked to focus on Section 6 (Ambient Air Monitoring), but that section is only two pages long, and, although I have done much analysis of pollutant concentrations, my primary expertise is in atmospheric boundary layers and dispersion. Therefore I have a few brief comments on section 6, and further comments on parts of the other sections related to atmospheric boundary layers and dispersion.

**Comments on Section 6 (Ambient Air Monitoring)** – This brief two page section reads like an abstract to a full detailed discussion. It needs to be expanded. It simply gives a few overview statements about the EPA’s current plan for review of SO<sub>2</sub> ambient monitoring. For example, it says “The agency is unaware of any recent technological advances in SO<sub>2</sub> measurements or forthcoming modifications to existing methods that should be considered in this review. Therefore the EPA does not anticipate raising any specific sampling and analysis methods issues for consideration in this IRP.” To this reviewer, this statement seems premature. As I suggest later in my comments, there has been much analysis using theories and observations concerning variations in the atmosphere of variables such concentrations in time and space which has not been considered by the EPA. These analyses would aid in planning and interpretation of sampler spacing and time averaging.

In lines 17-19 on p 6-2, it is said “SO<sub>2</sub> is unique in that there is a precedent to also use dispersion modeling in the implementation of its NAAQS”. This statement is puzzling because dispersion modeling is also used in most other pollutants with NAAQS (such as PM<sub>2.5</sub>, NO<sub>2</sub>, and ozone). Perhaps I am misinterpreting the EPA’s wording.

**Comments on all other sections of IRP** – I have similar comments as I made at June 2013 workshop. These include:

1) The EPA statistical relations between 5 min and one-hr average concentrations should take into account theoretical relations published 50 to 80 years ago based on atmospheric time and space spectra. The relations have been confirmed with observations of concentrations and meteorological variables, and are well described in, for example, Pasquill’s (1971) book. It is well-known that the time scale of boundary layer turbulence during summer days (about 10 min) is larger than during nights, which is why meteorologists seldom use five minutes as an averaging time. The atmosphere’s time and space scales and spectral shapes can now be reproduced faithfully by mesoscale meteorological models.

Additionally, there are several peer-reviewed papers prior to about 1980 where a power law relation was suggested based on observed maximum concentrations for various averaging times.

A rule of thumb is that max concentration is inversely proportional to averaging time raised to the 0.2 power. If we use this power law it can be shown that the new 1 hr SO<sub>2</sub> standard is actually 4 times more restrictive than the old 24 hr standard.

2) SO<sub>2</sub> concentrations from high density networks were collected around several power plants in the past (e.g., the Kincaid study) and could be used to develop formulas that show variations in space and averaging time. The information from this topic and the previous topic could be used to enhance the statistical relations developed by EPA and discussed in the IRP.

3) The population of relevant air quality (dispersion) models being reviewed should be expanded beyond the EPA's short distance model, AERMOD, since many Lagrangian puff (e.g., SCICHEM) and particle models (e.g., LODI) have been recently developed and satisfactorily evaluated with observations. These models can better handle a full range of averaging times, as well as space and time variations in meteorology.

4) Regarding quantitative uncertainty studies of model systems, it is essential that the dispersion models and meteorological models be "fit-for-purpose". For example, a model should have scientific structure so that it is able to handle multiple averaging times and spatial variability.

## Dr. Daniel Jacob

**Key Policy Relevant Issues (Chapter 3):** *Building on key considerations and issues addressed in the last review, Chapter 3 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?*

I think that the questions are comprehensive and well-posed. I cannot think of additional issues that should be considered.

**Science Assessment (Chapter 4):** *Chapter 4 describes the plan for the Integrated Science Assessment (ISA), which will critically evaluate and integrate the scientific evidence on health effects due to sulfur oxides in the ambient air. To what extent does Chapter 4 clearly and adequately describe the scope, approach, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.*

Chapter 4 is overall very clear and adequate. I do have a few comments:

1. Section 4.3.2: IMHO EPA could do its literature searches much more efficiently. I recently consulted on an EPA contractor project where the literature search was done by the method described here and I found it to be a huge waste of time. Keywords are not useful, citations are, because any decent paper will cite previous important literature. I find that by using the Science Citation Index (or equivalent tools) to march forward in time, and references (usually gleaned from the Introduction) to go backward in time, I very quickly and efficiently collect all the papers relevant to a particular issue.
2. Page 4-10: Volcanoes are not mentioned but will clearly need close attention as sources of SO<sub>2</sub>.
3. Page 4-11: I don't understand what is meant by "median hourly maximum 5-minute average".
4. Page 4-11, lines 8-10: how about methanesulfonates? They are known carcinogens and are present in the atmosphere (Eatough is on the panel and I would like to know his opinion since he has published on this).

## **Dr. Farla Kaufman**

The draft Integrated Review Plan is well organized, with most sections being very well written. The tables and figures were quite useful.

### ***Key Policy Relevant Issues (Chapter 3):***

I found the scientific and policy issues to be well delineated. I appreciated the logical presentation of the material. I

### ***Policy Assessment and Rulemaking (Chapter 7):***

This section very clearly summarized the process for policy assessment and rulemaking for this review.

### ***Comment pertaining to Chapter 4:***

There is growing interest in detailed documentation of the methods and results of literature searches conducted for systematic reviews. Concerning the literature searches for the integrated science assessment, it could be useful to have the inclusion and exclusion criteria documented for each identified study. Will that be the practice in this review?

## Dr. David Peden

### Chapter 4, with the charge question listed below:

“Science Assessment (Chapter 4): Chapter 4 describes the plan for the Integrated Science Assessment (ISA), which will critically evaluate and integrate the scientific evidence on health effects due to sulfur oxides in the ambient air. To what extent does Chapter 4 clearly and adequately describe the scope, approach, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.”

My specific expertise includes controlled human exposures and my brief written comments are noted below. However, before I list these, I will state that overall, the IRP for the review of literature and science germane to the SO<sub>2</sub> standard seems very appropriate and inclusive issues related to this standard.

#### Specific Comments/Observations:

1. It will very important to determine if literature exists from animal, cell culture, epidemiological or controlled exposure approaches that address the impact of SO<sub>2</sub> on airway infection. Recent studies with other agents suggest that pollutants enhance occurrence and severity of viral infections. This is important as at rest, SO<sub>2</sub> is taken up by nasal tissues, which are the primary sites of initial infection of a number of infections agents, including influenza, rhinovirus and SARS. It is likely that levels of SO<sub>2</sub> required to be cofactors for infection may be less than those required to directly cause symptoms.
2. There is appropriate emphasis on examining the role of SO<sub>2</sub> in the context of combined or complex exposures. While this will not be entirely novel to the current review, the notion that SO<sub>2</sub> might enhance response to other agents, or vice versa, remains important. Better appreciation of mechanisms that modulate response to pollutants (including innate immune/inflammatory mechanisms, antioxidant detoxification mechanisms) may provide insight into specific ways in which SO<sub>2</sub> might prime a person for increased response to another agent or vice versa.
3. The impact of SO<sub>2</sub> on the mucociliary escalator is may be especially important in modifying response to PM

4. Impacts of SO<sub>2</sub> on direct effects on cardiovascular disease, or in augmenting the impact of PM on CV disease will be important.
5. Though not novel, impacts on persons with asthma will be important to assess
6. Additionally, the increases in persons with other chronic metabolic diseases that are impacted by other pollutants (e.g. PM) suggest an additional focus in examining the effect of SO<sub>2</sub> in these populations. Obesity, diabetes, COPD, both elderly and the very young are all appropriate populations to assess with regard to respiratory and systemic impacts of SO<sub>2</sub>
7. Additionally, increases in population BMI may change the impact of SO<sub>2</sub>. To the extent that increases in BMI modify dosimetry of SO<sub>2</sub>, this may change the pattern or tissue specificity of SO<sub>2</sub> exposure in these populations.
8. Effects of SO<sub>2</sub> on response to biological agents found in many environments (both

Finally, I wish to restate that these topics really fall into the questions posed in Chapter 4. I thought it was simply useful to identify specific foci within the broader questions.

## Dr. Richard Schlesinger

### CHAPTER 4

Overall, the Chapter clearly defines the scope, approach and specific issues for consideration.

#### Specific comments

p. 4-7, line 18. Intake dose sounds like it relates to drug delivery. I presume that this is referring to exposure concentration then to exposure regimen. That makes it consistent with the next term, exposure route.

p. 4-7, line 35-36. Depending upon the microenvironment, this could result in a broad range of two orders of magnitude. Perhaps the document should be more specific.

p. 4-14, line 5-7. This sentence is awkward. It should read, "What information is available to discern the relative contribution of SO<sub>x</sub> derived exogenously from ambient exposure to endogenous SO<sub>x</sub> and is there evidence for any alteration in function due to the former."

p. 4-15, line 33-38. This should also state, "...to what extent does information on the pattern of SO<sub>x</sub> exposure indicate the role of exposure regime in adverse health outcomes." The way the first sentence is written in the document, it is not clear that this important information will be evaluated. The time course for changes in health effects does not necessarily mean that the role of specific exposure regime in producing adverse effects will be noted.

p. 4-16, line 1-3. This is effectively the same information as indicated on page 4-14, lines 33-38 and in my comment above.

p. 4-17, lines 4-20. Many of these questions seem redundant. The entire list can be condensed.

## Dr. Elizabeth A. (Lianne) Sheppard

### Chapter 5: Quantitative Risk and Exposure Assessment

*To what extent does Chapter 5 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review?*

I believe the discussion of the scope, issues, and uncertainties is adequate.

*To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?*

In the prior review the first approach to exposure assessment relied on the existing monitoring network with 5-minute and/or 1-hour data. This network was assumed to represent “a broad characterization of national air quality and potential human exposures that might be associated with these concentrations.” The document appropriately indicates the spatial representativeness of the monitors is a key uncertainty. We now have much more information assembled (e.g., in the MESA Air exposure database) about where monitors are located and how such locations compare with where people live. This information should be incorporated to better characterize the representativeness of the monitors and to refine county-level summarizations to better represent the US population. A new exposure assessment could also take into account the misalignment of the existing network with target populations and fix this misalignment through appropriate weighting in the exposure analysis.

## Dr. Frank Speizer

### *Overall organization and clarity*

EPA has done an excellent job in describing the process to be used and the planned timeline to complete the work. As will be indicated below a major issue I believe not adequately addressed yet, but certainly hinted at, is the issue of the data base used to come up with the standard on the last review. Clearly the Administrator determined that not only would the standard be changed but that in the future more data were needed to reduce uncertainty in the selection of a 1 hour standard that would protect against 5-10 minute highs. My general concern is that EPA Staff may be underestimating the work load needed to address this issue with the potential added data obtained over the years.

### *Introduction (Chapter 1 and Schedule (Chapter 2)).*

Overall the presentation is done well. Important points of the law are specified and particularly, although done as a footnote, the basic elements of *indicator, averaging time, form and level* are well defined.

I think the Figure on Page 1-4 is important and although all the elements are present the “time flow” could be enhanced. It is well spelled out in the text; however, as presented the Figure looks as though CASAC and Public comment input are being simultaneously provided at all stages of the process and with the potential to go back to an earlier stage. It looks as though this is presented to save space on the page. More correctly the CASAC and public comment is really provided as one way arrows throughout the progression of the process and this would be better indicated by inserting the input along the path of the process rather than from the side.

With regard to the Schedule, table 2.1 on page 2-2 suggests that there is a potential for an REA Planning Document not receiving more than a cursory review and not really being considered as a Draft. It is not clear if this means that EPA intends to use the previous REA on SO<sub>2</sub> as the document to be considered again, and I fear that EPA will not build in sufficient time for external review to have input. This is particularly of concern as we get to Chapter 5 where the discussion of the previous REA comes up and the suggestion is made that the basis of changing the standard in 2009 was based on available 5 minute/1 hour data at that time. In my opinion this will have to be revisited in a serious way and this will need to be fully discussed when we get to the REA. Thus, indicating (“*if warranted*”) seems inappropriate.

### ***Key Policy Relevant Issues (Chapter 3)***

All of the key questions appear to be considered. One of the key issues is to gather the new data that potentially has been obtained from one of the key mandates of the 2009 Administrator's ruling. As indicated at the bottom of page 3-14 (and in section 1.3) for the first time EPA has required reporting from the states on 5 minute/1 hour concentrations. If this ruling has led to additional data this will be a critical activity to take place in this review. The previous conclusions on the relationship was based on limited data, yet was critical in making the jump to a new standard in terms of averaging time and level. EPA needs to budget sufficient time to revisit this arena as it will have the biggest impact on the potential for any change in the standard and their review will require evaluation by CASAC and public comment. It is not clear in Figure 3-1 on page 3-13 in the box labeled 'Consideration of Potential Alternative Standard(s)' that adequate description of what might be needed is included (again it is in the text).

### ***Science Assessment( Chapter 4)***

. I want to compliment the EPA for the thoroughness of this chapter. They have indicated a wide variety of questions and specific issues to be explored. In fact what is missing is a caveat that it may not be possible to adequately address all of the issue as there simply may be insufficient or no data or studies to add to the existing data base in some cases. In particular an important area that will be explored is the potential for different effects of SO<sub>2</sub> across different stages of life. Gathering this data and being able to attribute what effects are reported to SO<sub>2</sub> will be a challenge. Figure 4.1 is indicated as being taken from Figure III of the 2013 lead document. It needs to be redrafted with the exclusion of some parts that will not apply to this document. In particular mention of welfare effects and potentially ecosystems.

### ***Quantitative Risk and Exposure Assessment (Chapter 5)***

Except for the potential for finding new groups of people at risk or new outcomes in Chapter 4, I consider the work proposed for this Chapter to be the most critical component of the Review. It is clear that in 2009 there were limited data with which to conduct an assessment of the adequacy of a setting a level for the 1 hour standard that would protect susceptible populations of individuals from 5-10 minute exposures with an adequate margin of safety and the EPA and CASAC reached a reasonable consensus with the information they had. However, in reviewing the key basis summarized in Table 5-1 on page 5-8, it is clear that only a modest amount of data were available, and in reviewing the source of these data (Appendix A, Table A.5.1 in the 2009 document) the representativeness of the sites and the populations at risk in those sites could not be determined. In addition although 98 sites were used, many of these sites were located in the same areas and seem highly correlated within sites; thus further reducing the potential generalizability of the data. For example from table 5.1 for 2003 40 sites are indicated as reporting monitors but those 40 sites represent only 31 different towns. These issues are recognized in Table 5-2 in discussing uncertainties; however it is not clear from the language

used that there is sufficient planning to address them and this reviewer would like to be assured that they will be explored.

***Ambient Air Monitoring (Chapter 6)***

I believe others on the committee are better qualified than I to comment on this section; however, I would like to know of the currently running 431 monitors in operation nationwide how many locations are actually represented, what proportion are sited to monitor specific sources of SO<sub>2</sub>, and what proportion truly represent population exposure. (I assume they all are reporting 5 minute exposures).

***Policy Assessment and Rulemaking (Chapter 7)***

I suggest on page 7-2, line 4, after the words 'public health' add the words **with an adequate margin of safety**

## Dr. James Ultman

**Overall organization and clarity:** To what extent does the Panel find that the draft IRP clearly and appropriately communicates the plan for the current review of the primary SO<sub>2</sub> NAAQS and the key scientific and policy issues that will guide the review? To what extent are the decisions made in the last review, including the rationales for those decisions, clearly articulated?

I think that the document adequately discusses all of these points.

**Introduction (Chapter 1) and Schedule (Chapter 2):** To what extent does the Panel find that Chapters 1 and 2 clearly communicate the NAAQS legislative requirements, summarize the steps in the review process, summarize the history of the SO<sub>2</sub> NAAQS, and present the anticipated schedule for the current review?

Chapter 1 is clearly written, and provides an enlightening summary of legislative requirements and history of previous Sox reviews.

**Key Policy Relevant Issues (Chapter 3):** Building on key considerations and issues addressed in the last review, Chapter 3 presents a set of policy-relevant questions that will serve as a focus in this review. To what extent does the Panel find that these questions appropriately characterize the key scientific and policy issues for consideration in the current review? Are there additional issues that should be considered?

Chapter 2 is fine as written.

**Science Assessment (Chapter 4):** Chapter 4 describes the plan for the Integrated Science Assessment (ISA), which will critically evaluate and integrate the scientific evidence on health effects due to sulfur oxides in the ambient air. To what extent does Chapter 4 clearly and adequately describe the scope, approach, specific issues to be considered, and organization of the ISA? Please provide suggestions for any other issues that should be considered.

Chapter is well-written and comprehensive. Two specific items:

pg. 4-7. line 35-36. What were the considerations in choosing two orders of magnitude chosen as a cut-off for generally including a study in the ISA?

pg. 4-16, line 32-34. "Age" was (erroneously?) included in two categories of factors.

**Quantitative Risk and Exposure Assessment (Chapter 5):** Chapter 5 summarizes the key risk and exposure analyses from the last review, including associated uncertainties, and discusses our planned approach to considering the potential for additional analyses in the current review. To

what extent does Chapter 5 clearly and adequately describe the scope and specific issues, including the identification of the most important uncertainties, to be considered in developing the REA Planning Document for this review? To what extent is there additional information that should be considered or additional issues that should be addressed in considering the potential for risk and/or exposure analyses in the current review?

Generally speaking the chapter is well-written and quite detailed in the policy-relevant questions that will be addressed and the nature of improvements to the previous Sox REA that will be pursued.

As in the previous review, the REA will utilize a three-prong approach consisting of an air quality, exposure, and quantitative health risk analyses. In the air quality and exposure analyses, benchmark exposures will be used as a means of framing the possible impact of health effects. In the introduction to section 5.1, the benchmark values used in the previous REA and the rationale for choosing them should be explicitly stated.

The IRP mentions the distal shifting of SO<sub>2</sub> absorption with increased exercise levels because of increased ventilation and a switch from nasal to oral breathing (pg 4-13). This might have a substantial influence on lung dysfunction in children and workers that spend substantial time exercising outdoors. The current plan for the REA appears to consider moderate exercise only.

I suggest that the new ISA include a section that integrates existing data on the exercise effect. Then, if it appears possible, the new REA should also strive to incorporate a ventilation effect into the exposure analysis and quantitative risk assessment.

One minor comment: In section 5.1.1 that summarizes the key findings from the previous REA, the multiple levels of bulleted items are a bit confusing. Please try to rewrite this section so that there is only one level of bullets.

***Ambient Air Monitoring (Chapter 6):*** To what extent does Chapter 6 clearly and appropriately communicate, for the purposes of this plan, the key aspects of measurement methods and surveillance network requirements for the SO<sub>2</sub> NAAQS?

Only a minor comment: It is not clear how the 431 monitors mentioned on pg 6-2 (line 23) relates to the monitor numbers given in table 5.1.

***Policy Assessment and Rulemaking (Chapter 7):*** To what extent does Chapter 7 clearly summarize the general process for the policy assessment and rulemaking phase of this review?

This chapter is fine.

## Dr. Ronald Wyzga

***Introduction (Chapter 1) and Schedule (Chapter 2):*** To what extent does the Panel find that Chapters 1 and 2 clearly communicate the NAAQS legislative requirements, summarize the steps in the review process, summarize the history of the SO<sub>2</sub> NAAQS, and present the anticipated schedule for the current review?

By and large the IRP clearly communicates the various topics listed above. My only suggestions would be that the ISA highlight new information/results that were not considered in the previous review for SO<sub>2</sub>. This would facilitate subsequent reviews. I would also ask that the REA Planning Document identify criteria that would abet the decision to undertake or not undertake a new REA. It is also not clear whether the previous REA would be utilized as part of the review process if a new REA is not prepared.

I also want to make sure I understand the timeline associated with the previous reviews. As I understand it, the court remanded EPA's decision on a 5-minute standard in January, 1998, but there was no EPA formal response until June, 2010. Is this correct or were there other actions that took place during this 12+ year interval? If so, they should be described in more detail.