

This draft CASAC Panel report has been prepared for Panel discussion and concurrence. It has not been reviewed or approved by the Chartered CASAC and does not represent EPA policy.



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
WASHINGTON D.C. 20460

OFFICE OF THE ADMINISTRATOR  
SCIENCE ADVISORY BOARD

DATE

EPA-CASAC-14-XXX

The Honorable Gina McCarthy  
Administrator  
U.S. Environmental Protection Agency  
1200 Pennsylvania Avenue, N.W.  
Washington, D.C. 20460

Subject: CASAC Review of the EPA's *Integrated Review Plan for the Primary National Ambient Air Quality Standard for Sulfur Dioxide (External Review Draft - March 2014)*

Dear Administrator McCarthy:

The Clean Air Scientific Advisory Committee (CASAC) Augmented Sulfur Oxides Primary National Ambient Air Quality Standards (NAAQS) Review Panel held a public teleconference on April 22, 2014, to peer review the EPA's *Integrated Review Plan for the Primary National Ambient Air Quality Standard for Sulfur Dioxide (External Review Draft - March 2014)*, hereafter referred to as the Draft IRP. The CASAC's consensus responses to the agency's charge questions and the individual review comments from the CASAC Augmented Sulfur Oxides Review Panel are enclosed.

Overall, the CASAC finds the draft IRP to be well written. It clearly communicates the NAAQS legislative requirements, the review process, and the evolution of the sulfur dioxide (SO<sub>2</sub>) NAAQS. The CASAC has a few recommendations for strengthening the document that are presented below.

A useful description of decisions in the last review and the rationales for these decisions are presented in the draft document, especially the reasoning behind the new 1-hour standard to prevent health effects associated with 5-minute peak exposures to SO<sub>2</sub>. As part of the last rulemaking, the EPA for the first time required state reporting of either the highest 5-minute concentration for each hour of the day, or all twelve 5-minute concentrations for each hour of the day (USEPA, 2014a). The availability of this rich new data will allow a number of analyses that will shed further light on the extent to which different standards (including the current 1-hour standard) protect against health risks. The CASAC encourages the EPA to take full advantage of this new data and invest the time necessary to conduct relevant analyses.

The plan for the Integrated Science Assessment (ISA) clearly and appropriately describes the scope

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1 and approach of the planned review, and the organization of the planned ISA is reasonable. The  
2 CASAC has a few suggestions for further strengthening the planned ISA: a) EPA should review  
3 evidence of health effects across all life stages (including identifying gaps in knowledge and future  
4 research needs); b) the document should clearly articulate why some sections refer to sulfur oxides  
5 (SO<sub>x</sub>) and others refer to sulfur dioxide (SO<sub>2</sub>); c) when there is a lack of recent controlled human  
6 and epidemiological studies on SO<sub>2</sub>, EPA should be thorough in reviewing “older” human and  
7 epidemiological studies; d) to the extent possible the review should consider whether there is any  
8 evidence of health effects of other sulfur species; if specific chemical mixtures, sources, or  
9 exposure conditions have differential health effects; if there is any evidence of interactions with  
10 other pollutants; and if susceptible subgroups have been identified. The CASAC also suggests  
11 ensuring that the literature review is systematic and state of the art.

12  
13 The anticipated schedule presented by the EPA for the SO<sub>2</sub> NAAQS review suggests that there is  
14 potential for the Risk and Exposure Assessment (REA) planning document to get a less rigorous  
15 review. It is also not clear if the time line presented allows for the development and review of a  
16 REA document. The CASAC recommends that the EPA provide the criteria and process through  
17 which they will decide whether a new REA will be carried out. These criteria should allow for  
18 multiple scenarios, including the possibility that new analyses may not confirm previous results,  
19 and whether and how the new 5-minute SO<sub>2</sub> concentration data will reduce uncertainties identified  
20 in the previous REA. Given the availability of new data, the CASAC believes that an REA is  
21 likely to be necessary and encourages EPA to develop clear and systematic criteria to make this  
22 decision.

23  
24 For ambient air monitoring, the CASAC recommends the EPA reference the promulgation of the  
25 most recent Federal Reference Method (FRM) and the recent requirement for reporting 5-minute  
26 maximum hourly concentrations. In addition, the discussion of modeling vs monitoring should  
27 include a brief summary of the proposed “Data Requirements Rule” (May 13, 2014) and SO<sub>2</sub>  
28 monitoring and modeling Technical Assistance Documents (TADs) that were released in  
29 December, 2013. Finally, the population of relevant air quality models being reviewed should be  
30 expanded beyond the EPA’s near source plume model, AERMOD, since many models have been  
31 recently developed and satisfactorily evaluated against observation.

32  
33 The CASAC appreciates the opportunity to provide advice on the draft IRP and looks forward to  
34 the EPA’s response.

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36  
37 Sincerely,

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39  
40 Dr. H. Christopher Frey, Chair  
41 Clean Air Scientific Advisory Committee

42  
43  
44 Dr. Ana Diez-Roux, Chair  
45 CASAC Augmented Sulfur Oxides  
46 NAAQS Review Panel

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- 1
- 2 Enclosures
- 3

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**NOTICE**

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This report has been written as part of the activities of the EPA's Clean Air Scientific Advisory Committee (CASAC), a federal advisory committee independently chartered to provide extramural scientific information and advice to the Administrator and other officials of the EPA. The CASAC provides balanced, expert assessment of scientific matters related to issues and problems facing the agency. This report has not been reviewed for approval by the agency and, hence, the contents of this report do not necessarily represent the views and policies of the EPA, nor of other agencies within the Executive Branch of the federal government. In addition, any mention of trade names or commercial products does not constitute a recommendation for use. The CASAC reports are posted on the EPA website at: <http://www.epa.gov/casac>.

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Clean Air Scientific Advisory Committee (CASAC)**

**CHAIR**

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**U.S. Environmental Protection Agency  
Clean Air Scientific Advisory Committee (CASAC) Augmented  
Sulfur Oxides Primary NAAQS Review Panel**

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1 **Consensus Responses to Charge Questions on**  
2 **EPA's Integrated Review Plan for the Primary National Ambient Air Quality**  
3 **Standards for Sulfur Dioxide (External Review Draft)**  
4  
5

6 **Overall organization and clarity:**  
7

8 *To what extent does the Panel find that the draft IRP clearly and appropriately communicates the*  
9 *plan for the current review of the primary SO<sub>2</sub> NAAQS and the key scientific and policy issues that*  
10 *will guide the review? To what extent are the decisions made in the last review, including the*  
11 *rationales for those decisions, clearly articulated?*  
12

13 The EPA has done an excellent job in describing the process to be used and the planned timeline to  
14 complete the work. A useful description of decisions in the last review and the rationales for them  
15 are presented in Chapter 3, especially the reasoning behind the new 1-hour standard in the context  
16 of its ability to reduce 5-minute exposures of concern to SO<sub>2</sub>. With the availability of a much  
17 larger 5-minute data set as noted below, this topic will need to be revisited. The EPA may be  
18 underestimating the effort needed to address this issue.  
19  
20

21 **Chapter 1 (Introduction) and Chapter 2 (Schedule)**  
22

23 *To what extent does the Panel find that Chapters 1 and 2 clearly communicate the NAAQS*  
24 *legislative requirements, summarize the steps in the review process, summarize the history of the*  
25 *SO<sub>2</sub> NAAQS, and present the anticipated schedule for the current review?*  
26

27 These chapters clearly communicate the NAAQS legislative requirements and the review process,  
28 the evolution of the SO<sub>2</sub> NAAQS, and, for the most part, the schedule for the current review. It  
29 would be useful if the information in Table 2.1 on major milestones and target dates for the review  
30 process could also be presented as a timeline, especially with respect to the temporal overlap  
31 between the ISA and REA processes discussed on page 1-6.  
32

33 The timeline associated with the review completed in 1996 and the subsequent court remand in  
34 January 1998 regarding EPA's decision on a 5-minute standard is discussed on page 1-9. It took  
35 twelve years for this remand to be addressed in the June 2010 NAAQS revision. This section notes  
36 that EPA started to collect 5-minute SO<sub>2</sub> data in response to this remand (starting in 2003  
37 according to table 5-1), but the reasons for this delay and the activities of the agency during this  
38 period could be described in more detail.  
39

40 Table 2-1 on page 2-2 and its footnotes suggests that there is potential for the REA Planning  
41 Document to get a less rigorous review (e.g., a CASAC Panel "Consultation"). It is not clear if the  
42 timeline presented in this table allows for the development and review of a REA document, or if it  
43 assumes there will not be a REA in this review cycle. While there may not be much new literature  
44 on SO<sub>2</sub> health effects since the last REA was finalized in 2009, there is a much larger data set  
45 (many more sites and more years of data) of 5-minute and 1-hour SO<sub>2</sub> concentrations as shown in  
46 Table 5-1. To the extent that the 1-hour form and level promulgated in the 2010 revisions to the



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1 SO<sub>2</sub> NAAQS were based on estimates of risk from short-term (5 to 10 minutes) exposures as  
2 discussed in Chapter 5, this will have to be revisited and fully discussed when the need for a new  
3 REA for this review is considered. Thus, indicating “may not be warranted” in footnote 18 of  
4 Table 2-1 seems inappropriate.

### 7 **Chapter 3 - Key Policy Relevant Issues**

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

14 The policy-relevant questions presented in Chapter 3 are comprehensive and well-posed. There are  
15 no additional issues that should be considered.

17 One of the key issues is to gather the new data that potentially has been obtained from one of the  
18 key mandates of the 2009 Administrator’s ruling. As indicated at the bottom of page 3-14 (and in  
19 Section 1.3), the EPA has required reporting from the states on either the highest 5-minute  
20 concentrations for each hour of the day, or all twelve 5-minute concentrations for each hour of the  
21 day. If this ruling has led to additional data, the detailed assessment of this data will be a critical  
22 activity to take place in this review. The previous conclusions on the relationship of the 1-hour  
23 SO<sub>2</sub> standard of 75 ppb to provide protection against health effects associated with 5-minute peak  
24 exposure was based on limited data, yet was critical in making the jump to a new standard in terms  
25 of averaging time and level. The EPA needs to budget sufficient time to revisit this relationship as  
26 it will have the biggest impact on the potential for any change in the standard and their review of  
27 additional data will require evaluation by CASAC and public comment. It is not clear in Figure 3-1  
28 on page 3-13 in the box labeled ‘Consideration of Potential Alternative Standard(s)’ that adequate  
29 description of what might be needed is included.

### 32 **Chapter 4 - Science Assessment**

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

40 The CASAC finds that, overall, Chapter 4 clearly and appropriately describes the scope and  
41 approach of the planned review, and the list of issues to be evaluated is thorough. The  
42 organization of the planned ISA, as outlined in Appendix A of the draft IRP, is reasonable. The  
43 CASAC also recommends specifically addressing the following points in revising the draft IRP:

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- 1 • In reviewing the past and recent research findings regarding the exposures and effects  
2 across all life stages, it is important to specifically identify those research areas that lack  
3 adequate data so as to inform future research agendas.  
4
- 5 • SO<sub>x</sub>, instead of SO<sub>2</sub>, is frequently mentioned in this and other chapters of the draft  
6 IRP. The EPA should clarify the scientific rationale where SO<sub>x</sub> rather than SO<sub>2</sub> needs  
7 to be mentioned.  
8
- 9 • If there is a lack of recent controlled human and epidemiological studies on SO<sub>2</sub>, the  
10 EPA should be thorough in reviewing “older” human and epidemiological studies to see  
11 if: (1) other specific sulfur species may be important (e.g., S (IV) in particles from  
12 smelter emissions) in exacerbating asthma); (2) specific chemical mixtures, sources  
13 (e.g., volcanoes), or exposure conditions may be important for observed effects; and (3)  
14 susceptible subgroups could be identified.  
15
- 16 • As the levels of SO<sub>2</sub> continue to decline in many U.S. cities, in reviewing the recent  
17 epidemiological studies, EPA should discuss any finding of a lack of association  
18 in relation to the potential for lack of statistical power.  
19  
20

## 21 **Chapter 5 - Quantitative Risk and Exposure Assessment**

22  
23 *Chapter 5 summarizes the key risk and exposure analyses from the last review, including*  
24 *associated uncertainties, and discusses our planned approach to considering the potential for*  
25 *additional analyses in the current review. To what extent does Chapter 5 clearly and adequately*  
26 *describe the scope and specific issues, including the identification of the most important*  
27 *uncertainties, to be considered in developing the REA Planning Document for this review? To*  
28 *what extent is there additional information that should be considered or additional issues that*  
29 *should be addressed in considering the potential for risk and/or exposure analyses in the current*  
30 *review?*  
31

32 The CASAC finds Chapter 5 to be well written and it clearly describes the scope and specific  
33 issues, including uncertainties.  
34

35 The CASAC suggests that the EPA provide the criteria and process through which they will decide  
36 whether a new REA will be carried out. These criteria should allow for multiple scenarios,  
37 including the possibility that new analyses may not confirm previous results, and should consider  
38 whether and how new five-minute SO<sub>2</sub> concentration data will reduce uncertainties identified in  
39 the previous REA. Absent these criteria, the CASAC believes that a new REA should be  
40 performed, given the substantially larger number of monitoring sites reporting 5-minute SO<sub>2</sub>  
41 concentrations. At a minimum, these data can be used to develop new models that relate 5-minute  
42 and hourly SO<sub>2</sub> concentrations, assess the geographic representativeness of the selected cities and  
43 their proximity to where people live. To facilitate these analyses, the EPA should provide  
44 information on the location of the new SO<sub>2</sub> monitoring sites, the completeness of the dataset, any  
45 sources of bias or concern that would result from using these data, and their strategy for addressing  
46 the misalignment of the existing network with the target population through appropriate weighting

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1 in the exposure analysis.  
2

3 The CASAC also suggests that there should be a strategy for good interaction between the REA  
4 and the ISA. The new ISA should include a section that integrates existing data on the effect of  
5 exercise on the inhaled dose, and if possible the new REA should incorporate a ventilation effect.  
6

## 7 8 **Chapter 6 - Ambient Air Monitoring** 9

10 *To what extent does Chapter 6 clearly and appropriately communicate, for the purposes of this*  
11 *plan, the key aspects of measurement methods and surveillance network requirements for the SO<sub>2</sub>*  
12 *NAAQS?*  
13

14 Chapter 6 gives a brief overview of the measurement methods and surveillance network  
15 requirements for the SO<sub>2</sub> NAAQS. Section 6.1 notes that, at the moment when this short section  
16 was written, there appeared to be no new technologies that might be relevant for measurement of  
17 SO<sub>2</sub> in routine regulatory monitoring networks. The EPA should reference the promulgation of the  
18 most recent Federal Reference Method (FRM). The recent requirement for reporting 5-minute  
19 maximum hourly concentrations is noted; this will allow analysis of the relationship between these  
20 very short term exposures and the 1-hour concentrations that the revised NAAQS is based upon.  
21

22 The EPA requires a minimum number of “population exposure” SO<sub>2</sub> monitors be installed in urban  
23 areas based on the Population Weighted Emissions Index (PWEI) score, while other “source  
24 specific” SO<sub>2</sub> monitors have been required by state agencies or voluntarily installed. In addition,  
25 the proposed “Data Requirements Rule” (USEPA, 2014) will likely require additional “source  
26 specific” SO<sub>2</sub> monitors based on Core Base Statistical Area (CBSA) population and SO<sub>2</sub> emission  
27 thresholds. Of the current 431 monitors in operation nationwide, the EPA should indicate the  
28 proportion of monitors that are SO<sub>2</sub> source specific vs. the proportion that truly represent  
29 population exposure. Also, it is not clear how the 431 monitors mentioned on page 6-2 relate to  
30 the monitor numbers given in Table 5.1.  
31

32 With the number of source-specific monitors increasing due to the proposed “Data Requirements  
33 Rule” (USEPA, 2014), it is not clear if there is value in continuing to require the “population  
34 exposure” SO<sub>2</sub> monitors. If there is still value in these monitors, the EPA should include the PWEI  
35 (Emissions x Population/1,000,000) criteria that were used previously to calculate the minimum  
36 number of SO<sub>2</sub> monitors in each CBSA: PWEI > 1,000,000 (minimum of 3 monitors), PWEI  
37 between 10,000 - 1,000,000 (minimum of 2 monitors), PWEI between 5,000 - 10,000 (minimum of  
38 1 monitor), and PWEI < 5,000 (no monitors). In addition, the EPA should consider alternate  
39 population-emission metrics since the current approach targets CBSAs that cover large geographic  
40 areas. Instead, the EPA should consider normalizing the population and emissions in the PWEI  
41 calculation by the geographic area (Emissions/Area x Population/Area). In addition, since the  
42 highest SO<sub>2</sub> impacts from large SO<sub>2</sub> sources are generally limited to a 10-25 km radius, the EPA  
43 might consider a PWEI calculation based on actual SO<sub>2</sub> emissions from individual large point  
44 sources and the population within a 10-25 km radius around the source.  
45

46 The IRP states that dispersion modeling can be used in lieu of monitoring to potentially reduce the

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1 necessary size and distribution of a compliance monitoring network. On page 6-2, the IRP states  
2 “While monitoring data are a mainstay in determining compliance for all other criteria pollutants,  
3 SO<sub>2</sub> is unique in that there is a precedent to also use dispersion modeling in the implementation of  
4 its NAAQS.” This statement is a little ambiguous and could be clarified to state exactly how  
5 modeling can be used in the implementation of the SO<sub>2</sub> NAAQS, such as using modeling to  
6 officially designate areas as “attainment” or “nonattainment”.

7  
8 The discussion of modeling vs. monitoring should include a brief summary of the proposed “Data  
9 Requirements Rule” (USEPA, 2014b) and SO<sub>2</sub> monitoring and modeling Technical Assistance  
10 Documents (TADs) that were released in December 2013. It remains unclear at this time to what  
11 extent the future SO<sub>2</sub> monitoring network may be adequate for assessing compliance with the  
12 revised 1-hour SO<sub>2</sub> NAAQS. The upcoming SO<sub>2</sub> NAAQS documents need to include a substantial  
13 discussion of this issue as it relates to the monitoring network, with updates as appropriate as new  
14 rules and TADs are issued by the EPA.

15  
16 Currently, EPA’s regulatory-approved near source (less than 50 km) dispersion model is the  
17 American Meteorological Society (AMS)/US Environmental Protection Agency (EPA) Regulatory  
18 Model Improvement Committee (AERMIC) model, AERMOD. The population of relevant air  
19 quality (dispersion) models being reviewed should be expanded beyond AERMOD. Many  
20 Lagrangian puff models [e.g., the California Puff (CALPUFF) model and the Second-order  
21 Closure Integrated PUFF with chemistry added (SCICHEM) model], and particle models [e.g.,  
22 Lagrangian Operational Dispersion Integrator (LODI)] have been recently developed and  
23 satisfactorily evaluated against observations. These models can better handle a full range of  
24 averaging times, as well as space and time variations in meteorology.

## 25 26 27 **Chapter 7 - Policy Assessment and Rulemaking**

28  
29 *To what extent does Chapter 7 clearly summarize the general process for the policy assessment*  
30 *and rulemaking phase of this review?*

31  
32 Chapter 7 provides a brief overview of the purpose and process for the policy assessment and rule-  
33 making. The CASAC finds this overview to be clear and appropriate. The communication of the  
34 Policy Assessment process may be improved with the addition of a figure that presents a decision  
35 tree or flow chart summarizing this process, including key questions that will be addressed in the  
36 formulation of the final recommendation to the Administrator.

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1 **References**

- 2
- 3 USEPA (2014a). *Integrated Review Plan for the Primary National Ambient Air Quality Standard*
- 4 *for Sulfur Dioxide (External Review Draft – March, 2014).*
- 5
- 6 USEPA (2014b). Proposed data requirements rule for the 1-hour sulfur dioxide (SO<sub>2</sub>) Primary
- 7 National Ambient Air Quality Standard (NAAQS), Federal Register 79: 27446 - 27472, May 13,
- 8 2014.

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## Appendix A

### Individual 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 – March 2014)

Mr. George A. Allen.....	A-2
Dr. John Balmes .....	A-4
Dr. James Boylan .....	A-5
Dr. Aaron Cohen.....	A-8
Dr. Alison Cullen.....	A-10
Dr. Delbert Eatough.....	A-13
Dr. William Griffith.....	A-20
Dr. Steven Hanna .....	A-22
Dr. Jack Harkema.....	A-24
Dr. Kazuhiko Ito .....	A-25
Dr. Daniel Jacob.....	A-27
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Dr. Elizabeth A. (Lianne) Sheppard .....	A-32
Dr. Frank Speizer.....	A-33
Dr. Helen Suh .....	A-35
Dr. James Ultman .....	A-36
Dr. Ronald Wyzga.....	A-38

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## **Mr. George A. Allen**

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3 Overall organization and clarity: To what extent does the Panel find that the draft IRP clearly  
4 and appropriately communicates the plan for the current review of the primary SO<sub>2</sub> NAAQS and  
5 the key scientific and policy issues that will guide the review? To what extent are the decisions  
6 made in the last review, including the rationales for those decisions, clearly articulated?  
7

8 The draft plan is well organized and clearly describes the review plan. A very useful description of  
9 decisions in the last review and the rationales for them are presented in Chapter 3, especially the  
10 reasoning behind the new 1-hour standard in the context of its ability to reduce 5-minute exposures  
11 of concern to SO<sub>2</sub>.  
12

13

14

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

19

20 These chapters are a good summary of the process and history of the SO<sub>2</sub> NAAQS. The schedule  
21 presented in Chapter 2 is reasonable, except regarding the uncertainty an update to the REA.  
22 Although there is recent precedent for not issuing a REA document as part of a NAAQS review  
23 process (the Pb NAAQS), EPA may need to update the SO<sub>2</sub> REA based on the large amount of  
24 new 5-minute SO<sub>2</sub> data now available for re-analysis of the relationship between 1-hour and 5-  
25 minute concentrations. It is unclear if the review schedule presented in Table 2-1 allows sufficient  
26 time for development of a REA document; including tentative “if needed” REA target dates in this  
27 table would be helpful.

28

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

32

33 This chapter is a very brief summary of monitoring methods and monitoring network requirements.  
34 Section 6.1 properly notes that there are no new technologies that might be relevant for  
35 measurement of SO<sub>2</sub> in routine regulatory monitoring networks. The requirement in the 2010  
36 NAAQS revision for reporting 5-minute maximum hourly concentrations is noted; this will allow  
37 further analysis in this review of the relationship between these very short term exposures and the  
38 1-hour concentrations that the revised NAAQS is based on.

39

40 Section 6.2 briefly notes the options unique to SO<sub>2</sub> for using monitoring or modeling to  
41 demonstrate compliance with the NAAQS (p. 6-2, l. 13-22). The discussion of modeling vs.  
42 monitoring has been ongoing between EPA and monitoring agencies since the last revision to the  
43 SO<sub>2</sub> NAAQS in 2010, with the next step in the process being the proposed “Data Requirements  
44 Rule” issued by EPA on April 17:

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1 <http://www.epa.gov/airquality/sulfurdioxide/implement.html#apr14>  
2  
3 Because of this proposed rule-making and the related finalization of Technical Assistance  
4 Documents (TADS) for use of SO<sub>2</sub> monitoring and modeling in an agency's network design, it  
5 remains unclear at this time to what extent the existing SO<sub>2</sub> monitoring network may be adequate  
6 for assessing compliance with the revised 1-h SO<sub>2</sub> NAAQS. The upcoming SO<sub>2</sub> NAAQS review  
7 documents need to include a substantial discussion of this issue as it relates to the monitoring  
8 network, with updates as appropriate as new rules and TADS are finalized by EPA.  
9  
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**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.

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## Dr. James Boylan

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**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?

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

13  
14 **Introduction (Chapter 1) and Schedule (Chapter 2):** To what extent does the Panel find that  
15 Chapters 1 and 2 clearly communicate the NAAQS legislative requirements, summarize the steps  
16 in the review process, summarize the history of the SO<sub>2</sub> NAAQS, and present the anticipated  
17 schedule for the current review?

18  
19 **RESPONSE:** These items were clearly communicated.

20  
21 **Key Policy Relevant Issues (Chapter 3):** Building on key considerations and issues addressed in  
22 the last review, Chapter 3 presents a set of policy-relevant questions that will serve as a focus in  
23 this review. To what extent does the Panel find that these questions appropriately characterize the  
24 key scientific and policy issues for consideration in the current review? Are there additional issues  
25 that should be considered?

26  
27 **RESPONSE:** The policy-relevant questions were appropriate. On page 3-7, it is not clear what is  
28 meant by “With respect to a 5-minute standard, there were concerns about standard stability”. In  
29 addition, it is not clear why “...concerns related to the number of monitors needed and the  
30 placement of such monitors given the temporal and spatial heterogeneity of 5-minute SO<sub>2</sub>  
31 concentrations” would be any different than the concerns related to measurements of 1-hour SO<sub>2</sub>  
32 concentrations. I have no additional issues to be considered.

33  
34 **Science Assessment (Chapter 4):** Chapter 4 describes the plan for the Integrated Science  
35 Assessment (ISA), which will critically evaluate and integrate the scientific evidence on health  
36 effects due to sulfur oxides in the ambient air. To what extent does Chapter 4 clearly and  
37 adequately describe the scope, approach, specific issues to be considered, and organization of the  
38 ISA? Please provide suggestions for any other issues that should be considered.

39  
40 **RESPONSE:** This chapter clearly outlined the scope, approach, specific issues to be considered,  
41 and organization of the ISA. On page 4-11, the IRP states “What do monitoring, satellite data, and  
42 dispersion modeling results indicate regarding spatial patterns on neighborhood, urban, regional,  
43 and national scales?” Photochemical modeling should be added to the list since they can be used at  
44 urban, regional, and national scales. I have no additional issues to be considered.

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1  
2 **Quantitative Risk and Exposure Assessment (Chapter 5):** Chapter 5 summarizes the key risk and  
3 exposure analyses from the last review, including associated uncertainties, and discusses our  
4 planned approach to considering the potential for additional analyses in the current review. To  
5 what extent does Chapter 5 clearly and adequately describe the scope and specific issues, including  
6 the identification of the most important uncertainties, to be considered in developing the REA  
7 Planning Document for this review? To what extent is there additional information that should be  
8 considered or additional issues that should be addressed in considering the potential for risk and/or  
9 exposure analyses in the current review?

10  
11 **RESPONSE:** Chapter 5 clearly and adequately describes the scope and specific issues to be  
12 considered in developing the REA. I have no additional issues to be considered.

13  
14 **Ambient Air Monitoring (Chapter 6):** To what extent does Chapter 6 clearly and appropriately  
15 communicate, for the purposes of this plan, the key aspects of measurement methods and  
16 surveillance network requirements for the SO<sub>2</sub> NAAQS?

17  
18 **RESPONSE:** Chapter 6 gives a brief overview of the measurement methods and surveillance  
19 network requirements for the SO<sub>2</sub> NAAQS. It would be good for the IRP to include the PWEI  
20 (Emissions x Population/1,000,000) criteria that were used previously to calculate the minimum  
21 number of SO<sub>2</sub> monitors in each CBSA: PWEI > 1,000,000 (minimum of 3 monitors), PWEI  
22 between 10,000 - 1,000,000 (minimum of 2 monitors), PWEI between 5,000 - 10,000 (minimum of  
23 1 monitor), and PWEI < 5,000 (no monitors). In addition, EPA should consider alternate  
24 population-emission metrics since the current approach unfairly targets CBSAs that cover large  
25 geographic areas. Instead, EPA should consider normalizing the population and emissions in the  
26 PWEI calculation by the geographic area (Emissions/Area x Population/Area). Below are three  
27 example CBSAs, where the area of each block is 10 km x 1 km = 10 km<sup>2</sup>.

28  
29 CBSA X

30  $PWEI = (10 \times 1,000 \text{ TPY}) * (10 \times 100,000 \text{ pop})/1,000,000 = 10,000$

31  $\text{Area Normalized PWEI} = [(10 \times 1,000 \text{ TPY})/100 * (10 \times 100,000 \text{ pop})/100]/1,000,000 = 1.0$

Population=100,000 SO <sub>2</sub> =1,000 TPY	Population=100,000 SO <sub>2</sub> =1,000 TPY	Population=100,000 SO <sub>2</sub> =1,000 TPY	Population=100,000 SO <sub>2</sub> =1,000 TPY	Population=100,000 SO <sub>2</sub> =1,000 TPY
Population=100,000 SO <sub>2</sub> =1,000 TPY	Population=100,000 SO <sub>2</sub> =1,000 TPY	Population=100,000 SO <sub>2</sub> =1,000 TPY	Population=100,000 SO <sub>2</sub> =1,000 TPY	Population=100,000 SO <sub>2</sub> =1,000 TPY

32  
33 CBSA Y

34  $PWEI = (1,000 \text{ TPY}) * (100,000 \text{ pop})/1,000,000 = 100$

35  $\text{Area Normalized PWEI} = [(1,000 \text{ TPY})/10 * (100,000 \text{ pop})/10]/1,000,000 = 1.0$

Population=100,000 SO <sub>2</sub> =1,000 TPY
--

36  
37 CBSA Z

38  $PWEI = (10,000 \text{ TPY}) * (1,000,000 \text{ pop})/1,000,000 = 10,000$

39  $\text{Area Normalized PWEI} = [(10,000 \text{ TPY})/10 * (1,000,000 \text{ pop})/10]/1,000,000 = 100$

Population=1,000,000 SO <sub>2</sub> =10,000 TPY
---

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1  
2 Although CBSA X and CBSA Z have identical PWEI scores, the population exposure in CBSA Z  
3 is 100 times that of CBSA X. Also, CBSA X has a PWEI score that is 100 times higher than  
4 CBSA Y; however, they both have identical population exposures. In addition, since the highest  
5 SO<sub>2</sub> impacts from large SO<sub>2</sub> sources are generally limited to a 10-25 km radius, EPA might  
6 consider a PWEI calculation based on actual SO<sub>2</sub> emissions from individual large point sources  
7 and the population within a 10-25 km radius around the source.

8  
9 The IRP states that dispersion modeling can be used in lieu of monitoring to potentially reduce the  
10 necessary size and distribution of a compliance monitoring network. The discussion of modeling  
11 vs. monitoring should include a brief summary of the proposed “Data Requirements Rule” (April  
12 17, 2014) and SO<sub>2</sub> monitoring and modeling Technical Assistance Documents (TADs) that were  
13 released in December, 2013.

14  
15 ***Policy Assessment and Rulemaking (Chapter 7):*** To what extent does Chapter 7 clearly  
16 summarize the general process for the policy assessment and rulemaking phase of this review?

17  
18 **RESPONSE:** Chapter 7 does of good job of summarizing the policy assessment and rulemaking  
19 process.

20

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## Dr. Aaron Cohen

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

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

8 Specific suggestions/comments:

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

11

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

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

16 Specific suggestions/comments:

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

20

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

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

25

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

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

29 Specific suggestions/comments:

- 30 • Page 4-2, line 32: should read Figure 4.1 not Figure 3.1.
- 31 • Page 4-5, lines 8-9: are the EPA studies peer-reviewed?
- 32 • Page 4-5, lines 14-15: suggest changing "whether the results are..." to "...but not the study  
33 results."
- 34 • Page 4-6, lines 9-10: Suggest deleting from "which refers...population," Substitute  
35 "which refers to inaccuracies in the characterization of the exposures of study  
36 participants,"
- 37 • Page 4-8, line 26: the "five-level hierarchy" of evidence used by EPA is described on page  
38 4-16, lines 19-24. Suggest moving to Page 4-8.
- 39 • Page 4-9, lines 3-5: Said earlier, repetitive.
- 40 • Page 4-9, line 8: suggest "exposure response" rather than "concentration-response."
- 41 • Page 4-9, Section 4.3.5: Not really sure from this description what the QMP really entails.  
42 Lines 28-32 appear to describe the QA/QC of USEPA intra-mural research but a link to the  
43 actual QMP processes might help here.

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- 1       • 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  
2 exposure” then this begs the questions on lines 11-14 on page 3-14 and lines 24-26 on page  
3 3-15.  
4       • Pages 4-16/17, lines 34/1: Re. “...some factors are (e.g., age) interconnected and may  
5 influence risk through multiple avenues.” What is age interconnected with and what  
6 avenues?  
7

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

9 Chapter 5 provides a clear description of the REA from the 2010 review and describes clearly  
10 and completely the scope and specific issues, including the identification of the most important  
11 uncertainties, to be considered in developing the REA Planning Document for this review. The  
12 focus is largely on reducing the uncertainties in the current 1-hour NAAQS (see Table 5-2) but  
13 EPA’s general formulation is sufficiently broad to allow for changes in the scope of the REA  
14 that might be warranted by the new ISA.  
15

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

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

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

20 Chapter 7 is very clear and succinct.  
21

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## **Dr. Alison Cullen**

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

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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?

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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.

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23  
24  
25

#### **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.

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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?

35  
36

#### **5.2.2 Exposure Assessment**

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41

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.

42  
43  
44

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

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1 review EPA stated that 5 minute peaks “will likely cause adverse health impacts in a subset of  
2 asthmatics”, thus with the 5 minute concentration data now available, another look is warranted to  
3 gauge the extent to which this might be expected. Is there a possibility with any newly available  
4 epidemiological studies to use metagenomic data to identify sensitive groups via genetic markers  
5 and/or to get an estimate of the relative risk of health effects associated with various genetic  
6 markers?  
7

### 8 **Section 5.2.3 Risk Assessment**

9 This section is clear and comprehensive. Regarding the question as to whether there are any  
10 possible newly identified at-risk study groups, I refer to the previous point above. Aside from  
11 metagenomic approaches what other means should be used to identify such potential groups? A  
12 review of epidemiological evidence is certainly one component, to see what studies might now be  
13 available for the QRA.  
14

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

16 Regarding exposure assessment and representativeness of the two study areas, it is stated that they  
17 have two differing emissions and population density profiles. Do they have similar climates?  
18 Similar demographics? With the availability of recently collected 5-minute ambient monitor  
19 concentrations and the idea that exposure estimates could be developed for other study areas – it is  
20 interesting to consider the impact of past selection of study areas. This can help inform the  
21 approach to selection moving forward.  
22

23 **5.2.4 Uncertainty and variability** – this section tackles the question - what were the most  
24 significant sources of uncertainty and variability in the prior analysis, and will these be informed  
25 by additional data and studies available this time? The WHO 2008 approach will keep the current  
26 review consistent with past review. The additional 5 minute concentration data of recent years  
27 could help to address continuing issues such as related to analysis of uncertainty due to the  
28 estimation of 5 minute maximum SO<sub>2</sub> values from longer averaging time data. Might also help  
29 with an assessment of how representative the two study locations are of the US as a whole, and  
30 may also inform efforts to add exposure estimates for other study areas. Finally the relationship of  
31 5 minute peaks to other averaging times will be relevant to considerations of responses in  
32 asthmatics of various levels of severity.  
33

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

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

37 It would be useful to say more about what the proportional approach entails (on page 5-4), just a  
38 sentence or two would help, although a citation to the last REA is given so perhaps that is  
39 sufficient for directing readers.  
40

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

42 Sixth bullet under section 5.1.2 regarding the shape of exposure-response relationships for  
43 asthmatics with more severe disease than those tested in chamber studies, is there any information  
44 about this issue for other air pollutants that could shed light here?  
45

46 Eighth bullet under section 5.1.2 regarding uncertainty about how well the two modeled areas in



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- 1 Missouri are representative of other locations in the US - is there more information somewhere on
- 2 the climate and demographic differences between these two locations, or between Missouri and the
- 3 rest of the country?
- 4

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## **Dr. Delbert Eatough**

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### **Chapter 4: Science Assessment**

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

10

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

14

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

16

#### **Nomenclature:**

17

18  
19 The NAAQS under review is that for SO<sub>2</sub>. The primary health effect which has justified the  
20 creation of this NAAQS is the morbidity effect on asthmatics exposed to ambient SO<sub>2</sub>, with the  
21 casual relationship between exposure and morbidity effects based on both human exposure and  
22 epidemiological studies. SO<sub>x</sub> (sulfur oxides in the atmosphere) refers to SO<sub>2</sub> plus all the products  
23 of SO<sub>2</sub> chemistry in the atmosphere. These include gas phase SO<sub>3</sub> (which may also be emitted  
24 from sources). As pointed out in the assessment plan and in the assessment for the 2010 standard  
25 review, SO<sub>3</sub>(g) will quickly react with water in the atmosphere to form sulfuric acid, which is both  
26 hygroscopic and reactive with ammonia. This results in the facile conversion of SO<sub>3</sub> to sulfuric  
27 acid aerosol and subsequently to the rapid formation of sulfate and acid sulfate aerosols. Thus the  
28 gas phase SO<sub>3</sub> species is not important with respect to health effects. Furthermore, both sulfuric  
29 acid aerosol and ammonium sulfate aerosols, whether acidic or completely neutralized, have been  
30 shown to not have a significant effect on asthmatics at concentrations comparable to those for  
31 which observable SO<sub>2</sub> effects are seen. This is all well outlined in the previous assessment. I find  
32 it strange and awkward, therefore, that reference through this chapter (and other chapters) put the  
33 emphasis in both the chapter outline and throughout the text on SO<sub>x</sub>. I think the intent of the  
34 review would be more clear if the reference was generally to only SO<sub>2</sub>, with other sulfur oxides  
35 being mentioned where needed or appropriate.

36

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1 **Relationship to Sources:**  
2

3 A potentially enlightening exercise might be to examine if any relationship exists between the  
4 results of epidemiological studies and the source of SO<sub>2</sub> for a given epidemiological study. I  
5 suggest this because it might enlighten whether particulate S(IV) (e.g. absorbed SO<sub>2</sub>) might be  
6 important in exacerbation of asthma. This suggestion is based on the early laboratory studies of  
7 Amdur (1971) and Alarie (1973) which indicated that exposure to both SO<sub>2</sub> and metal oxides  
8 present in smelter emissions resulted in an enhanced animal response and that the resulting  
9 aerosols were irritating. Postulating that the work of Amdur might reflect the present of stable  
10 metal sulfite species in the aerosols studied, and that the formation of such aerosol species, rather  
11 than aerosol sulfate, might explain the results of the EPA CHESS study in the Salt Lake City  
12 environment with substantial impact from Cu smelter emissions (EPA 1974), we conducted studies  
13 on S(IV) associated with ambient aerosols. This work demonstrated that stable transition metal ion  
14 - sulfite species existed in aerosols associated with smelter emissions (Smith 1976, Eatough 1979,  
15 Eatough 1980) and could be formed in aging smelter plumes (Eatough 1981a, Eatough 1982). The  
16 sulfite species were present at from 10 to 30 mol % of the sulfate species in these smelter  
17 associated aerosols. The sulfite species were less important in urban or coal-fired power plant  
18 plumes (Eatough 1978). We also demonstrated that stable Fe(III) –S(IV) aerosols could be  
19 routinely generated in the laboratory (Hilton 1979). The measurement, stability and formation of  
20 these inorganic S(IV) species in aerosols has been reviewed (Eatough 1983). These S(IV) species  
21 were present in emission from all smelters studied, were present in lower amounts in emissions  
22 from coal-fired power plants and additional material was formed during plume transport in smelter  
23 plumes. The amount of the S(IV) species, relative to sulfate average 0.1 mol S(IV)/mol sulfate in  
24 the coal fired power plant plumes and 0.5 mol S(IV)/mole sulfate in aged smelter plumes. The  
25 formation of S(IV) in smelter plumes increased with decreasing acidity of the aerosol.  
26

27 If these S(IV) containing aerosols identified in the above reviewed research account for the  
28 enhanced effect of SO<sub>2</sub> in the presence of transition metal containing aerosols in animal exposure  
29 studies, then this class of compounds may be important in the interpretation of the morbidity  
30 effects associated with exposure to pollution from refinery sources. A careful review of pertinent  
31 epidemiological literature may inform this postulate.  
32

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

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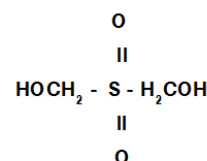
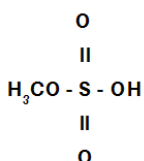
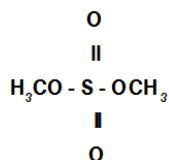
1  
2 Probably a more fruitful set of data to evaluate the relative importance of aerosol S(IV) species  
3 associated with smelter emissions would involve past epidemiological studies from about two to  
4 three decades ago when smelter emission were much more significant, for example from the TX  
5 smelters in El Paseo (ASARCO Cu smelter, closed in 1999), and Corpus Christi (ASARCO Pb  
6 smelter, closed in 1985), Az smelters (ASARCO Cu smelter in Hayden, currently operating and  
7 Phelps Dodge Cu smelter in Douglas, closed in 1987), from the Kennecott Cu smelter in Magna,  
8 UT prior to construction of the tall stack, from the Tacoma WA smelter (American Smelting and  
9 Refining, a Cu smelter specializing in high As ore refining, closed in 1985), or the smelters in  
10 Montana (ASARCO Pb smelter in East Helena, closed in 2001, Anaconda Cu smelter in  
11 Anaconda, closed in 1981) and Idaho (Bunker Hill Pb smelter in Kellogg, closed in 1982). I know  
12 that several epidemiological studies were conducted at these locations, but I am not familiar with  
13 the results of these studies with respect to asthma exacerbation. I recommend that EPA look at this  
14 older data to see if an estimate of the relative potency of SO<sub>2</sub> and smelter associated aerosol S(IV)  
15 species can be determined. There will not be data on the concentrations of S(IV) in the aerosols  
16 emitted from these sources, so total particulate exposure would need to be used as a surrogate. The  
17 importance of elucidating the effect of these exposures is correctly alluded to in the ISA on Page 4-  
18 12, Line 11.

19

## 20 Organic Oxysulfur Compounds in the Atmosphere

21

22 This section was added to my preliminary comments to provide a written response to the question  
23 raised in the preliminary comments by Dr. Daniel Jacob. Compounds identified by BYU and  
24 discussed below include:



### 25 Dimethyl Sulfate

### 26 Monomethyl Sulfuric Acid

### 27 Bis-Hydroxymethyl Sulfone

28 *Alkyl Sulfates.* We have previously identified monomethyl sulfuric acid and dimethyl sulfate in  
29 power plant plumes (Lee 1980, Eatough 1981b, Hansen 1987)) and in the Los Angeles Basin  
30 (Eatough 1986, Hansen 1986). The alkyl sulfates have been shown to be present in emissions from  
31 both coal and oil-fired power plants (Eatough 1981b). In addition, formation of dimethyl sulfate  
32 during plume transport has been seen in the plumes of both a oil-fired and a coal-fired power plant  
33 (Hansen 1987). Dimethyl sulfate did not form in the plume of the oil-fired power plant studied  
34 while it resided in a fog bank, but formation was seen after the plume exited the fog bank. The rate  
35 of conversion of SO<sub>2</sub> to dimethyl sulfate was about 0.4 mole %/hr in the oil fired power plant  
36 plume and about 0.05 mole %/hr in the coal fired power plant plume. Particulate phase dimethyl  
37 sulfate dominated in these two studies. In the Los Angeles Basin studies (Eatough 1986) dimethyl  
38 sulfate was only seen in air masses not imbedded in a fog bank, i.e. generally in the inland area.  
39 Gas phase dimethyl sulfate was the dominate species in these studies, was present at highest  
40 concentrations in transported plumes in the Inland Empire and was seen to exceed 10 mole % of  
the total sulfur oxides present. It should be pointed out that at the time of these studies, substantial  
SO<sub>2</sub> emission from power plants were present in the Basin..

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1  
2 Dimethyl sulfate is a mutagen and suspected human carcinogen, so it's presence may be important  
3 with respect to toxic species, but I am not aware of any data indicating that inhalation will  
4 exacerbate asthma.

5  
6 ***Bis Hydroxymethyl Sulfone.***

7  
8 Several different methods of analysis of particulate samples collected from the plumes of coal-fired  
9 power plants or from areas heavily impacted by coal-fired boilers indicated that a S(IV) compound  
10 distinctly difference form inorganic S(IV) was present in the samples (Eatough 1978, Eatough  
11 1981, Richter 1981). This compound was subsequently identified as bis-hydroxymethyl sulfone  
12 (Eatough 1984). The sulfone was usually present in emissions from coal- or oil-fired power plants  
13 at mol ratios of about 0.5 (range of 0.1 to 1.0) compared to sulfate (Eatough 1983). First order  
14 formation of the sulfone was observed in plumes from six different power plants at rates of from  
15 0.4 to 3.0 % SO<sub>2</sub>/hr. with the observed rate being inversely proportional to atmospheric water  
16 partial pressure (Eatough 1983). The sulfone was found in highest concentrations in the Las  
17 Angeles Basin in inland samples (mol fraction comparable to sulfate), but was not seen in coastal  
18 samples impacted by fog or clouds (Farber 1982).

19  
20 Toxicological data is not available for bis-hydroxymethyl sulfone.

21  
22 ***Other Organic Oxysulf Comounds.***

23  
24 Aerosol phase methane sulfonic acid (Panter 1980) and gas phase ethylene sulfite (Jones 1974)  
25 have been identified in atmospheres impacted by emission from coal fired power plants, but only at  
26 concentrations much less than the above described species.

27  
28

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1 **Consistency of Results**

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

9  
10 **Relationship to Sulfate**

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

17  
18 **Minor Points**

19  
20 Page 4.1, line15. There is no section 3.4.  
21 Page 4.4, line 8. Section 4.3.2. should be the reference.  
22 Page 4.6, line 14. Reference is not in reference list.

23  
24 **Chapter 3: Key Policy-Relevant Issues**

25  
26 Charge Question: Building on key considerations and issues addressed in the last review,  
27 Chapter 3 presents a set of policy-relevant questions that will serve as a focus in this review. To  
28 what extent does the Panel find that these questions appropriately characterize the key scientific  
29 and policy issues for consideration in the current review? Are there additional issues that should be  
30 considered?

31  
32 The material under the first bullet, and the first subbullet on page 3-14 (line 11) underscores my  
33 uncertainty of the guiding hypothesis in the review of the SO<sub>2</sub> standard. It seems to me that the last  
34 review of the standard resulted in identification of a link between SO<sub>2</sub> exposure and the  
35 exacerbation of asthma as the underlining scientific evidence on which the SO<sub>2</sub> standard was  
36 based. Yet this statement (and related points throughout the document) seem to imply that all SO<sub>x</sub>,  
37 including both gas and particulate associated species is the key indicator. There seems to me to be  
38 an inconsistency with regard to this point that is somewhat confusing.

39  
40 **Chapter 6: Ambient Air Monitoring**

41  
42 Charge Question: To what extent does Chapter 6 clearly and appropriately communicate, for  
43 the purposes of this plan, the key aspects of measurement methods and surveillance network  
44 requirements for the SO<sub>2</sub> NAAQS?

45  
46 My comment here is really a repeat of the comment above. The charge question seems clear and

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1 correctly framed. Yet the first paragraph states (bold emphasis mine) “This chapter describes plans  
2 considering these aspects of the ambient air monitoring program for **sulfur oxides** which includes  
3 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**  
4 NAAQS, ...” And then, as appropriate, only SO<sub>2</sub> sampling is discussed.

5  
6 I would suggest that EPA should be more consistent in stating this is a review of the SO<sub>2</sub> standard.

7  
8 The suggestion inherent in many sections of this chapter that equal weight will be given to  
9 understanding other components, such as sulfate, cannot, of course be met. Only the SO<sub>2</sub>  
10 monitoring program will allow evaluation of short term (5-10 minutes) exposures, which appear to  
11 me to be a very important part of new data which will be examined in the current review.

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1

## **Dr. William Griffith**

2

### **Comments on Chapter 5**

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

8

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

15

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

26

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

34

35 Other minor comments:

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

39

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

43

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

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- 1 P5.13 lines 8-13. Will the literature be reviewed for other additional approaches to be considered?
- 2

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1

## **Dr. Steven Hanna**

2

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

4

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.

10

11

**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.

23

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.

28

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

31

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.

40

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

44

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- 1 more restrictive than the old 24 hr standard.
- 2
- 3 2) SO<sub>2</sub> concentrations from high density networks were collected around several power plants in
- 4 the past (e.g., the Kincaid study) and could be used to develop formulas that show variations in
- 5 space and averaging time. The information from this topic and the previous topic could be used to
- 6 enhance the statistical relations developed by EPA and discussed in the IRP.
- 7
- 8 3) The population of relevant air quality (dispersion) models being reviewed should be expanded
- 9 beyond the EPA's short distance model, AERMOD, since many Lagrangian puff (e.g., SCICHEM)
- 10 and particle models (e.g., LODI) have been recently developed and satisfactorily evaluated with
- 11 observations. These models can better handle a full range of averaging times, as well as space and
- 12 time variations in meteorology.
- 13
- 14 4) Regarding quantitative uncertainty studies of model systems, it is essential that the dispersion
- 15 models and meteorological models be "fit-for-purpose". For example, a model should have
- 16 scientific structure so that it is able to handle multiple averaging times and spatial variability.
- 17

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1

**Dr. Jack Harkema**

2

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

6

7 The purpose, plan and process of the Policy Assessment and Rulemaking in Chapter 7 are for the  
8 most part clearly and concisely articulated in Chapter 7. The authors, however, may consider  
9 providing a “Decision Tree” figure that summarizes the policy assessment process including key  
10 questions that will be addressed in the formulation of the final recommendation to the  
11 Administrator.

12

13 Specific Comments:

14

15 7.1 Policy Assessment. In general, the purpose and plan of the PA is clearly articulated in this  
16 section. Some examples of policy-relevant questions, however, could be added to the text. In  
17 addition, a summarizing figure (“decision tree”), outlining the processes of assessment and  
18 decision-making steps, would also be helpful to those who are formulating the final  
19 recommendation to the Administrator.

20

21 7.2 Rulemaking. The process is clearly and succinctly stated. On page 7-3, line 5, why is the length  
22 of the public comment period, “60 to 90 days”, so vague? Shouldn’t it be either 60 or 90 days?

23

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1

**Dr. Kazuhiko Ito**

2

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

8

9 **Response:** The draft IRP clearly communicates the plan for this review. The decisions and the  
10 rationales from the previous review (e.g., the “definitive evidence” came from the 5-10 minute  
11 controlled human studies with exercising asthmatics, and “supporting evidence” came from  
12 observational studies of respiratory symptoms, ED visits, and hospitalizations) were also clearly  
13 described. In particular, the description of the areas of uncertainty (e.g., the relationship between  
14 5-min values to longer averaging times) was very helpful in setting up the focus for the current  
15 review.

16

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

21 **Response:** Both chapters are clear.

22

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

28

29 **Response:** The chapter lists most relevant policy-relevant questions, and I cannot think of  
30 additional questions at the moment. However, I think that, to the extent that it is unlikely (I could  
31 be wrong on this, of course) that we will have a new controlled human study on SO<sub>2</sub> in the current  
32 review, the “definitive evidence” established in the human control studies on exercising asthmatics  
33 will be unchallenged. Thus, the focus will be on the questions that can be addressed with  
34 observational epidemiological studies. Then, the challenge will be that we will have studies that  
35 may have substantively lower levels of SO<sub>2</sub> compared to the past studies, and the evaluation will  
36 need to distinguish a lack of association from a lack of statistical power due to reduced exposure  
37 contrast. This is probably not something that can be incorporated as part of policy-relevant issues,  
38 so I will comment on this for Chapter 4.

39

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

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1 *considered.*

2

3 **Response:** I have several comments so far below:

4 - I thought this chapter very thoroughly describes the scope, approach, and issues to be  
5 considered for the current review.

6

7 - I am not sure if it is appropriate for the EPA to do this, but if the ISA plans to consider  
8 studies that are published or accepted for publication up to two months before the external  
9 review draft of the ISA (which would put the cut-off to be April 2015), it may be helpful  
10 for the EPA to identify ongoing studies and send the investigators the review criteria as  
11 well as the list of key policy-relevant questions. Obviously this is too late for experimental  
12 studies, but for the studies that are currently analyzing data, it may come down to a matter  
13 of running a few additional models, or procuring 1-hr max SO<sub>2</sub> in addition. This is not a  
14 suggestion for the IRP, but I thought it could be important. The researchers are not  
15 necessarily paying attention to what

16

17 - One potential scenario is that, we may have much lower SO<sub>2</sub> levels in some of the cities in  
18 the studies eligible for this round of review compared the previous, due either to general  
19 reduction in emissions or changes in fuel types used. This can lead to reductions in  
20 exposure contrasts for both the short-term (temporal) and long-term (spatial) studies,  
21 resulting in reduced statistical power. The ISA review will need to be careful about  
22 distinguishing a lack of association vs. a lack of statistical power. In addition, reduced  
23 levels of SO<sub>2</sub> can affect several of the specific issues to be addressed: the exposure error  
24 may be augmented for both measurements and prediction; the correlation with other  
25 pollutants may become weaker, etc. These points may sound too convoluted to be on the  
26 “Specific Issues”, so I just want the EPA to be aware of them.

27

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**Dr. Daniel Jacob**

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

8

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

11

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

17

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

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

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**Dr. Farla Kaufman**

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

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

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

10

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

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

14

15 ***Comment pertaining to Chapter 4:***

16 There is growing interest in detailed documentation of the methods and results of literature  
17 searches conducted for systematic reviews. Concerning the literature searches for the integrated  
18 science assessment, it could be useful to have the inclusion and exclusion criteria documented for  
19 each identified study. Will that be the practice in this review?  
20

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## Dr. David Peden

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

5

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

11

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

16

17 Specific Comments/Observations:

18

- 19 1. It will very important to determine if literature exists from animal, cell culture,  
20 epidemiological or controlled exposure approaches that address the impact of SO<sub>2</sub> on  
21 airway infection. Recent studies with other agents suggest that pollutants enhance  
22 occurrence and severity of viral infections. This is important as at rest, SO<sub>2</sub> is taken up by  
23 nasal tissues, which are the primary sites of initial infection of a number of infections  
24 agents, including influenza, rhinovirus and SARS. It is likely that levels of SO<sub>2</sub> required to  
25 be cofactors for infection may be less than those required to directly cause symptoms.  
26
- 27 2. There is appropriate emphasis on examining the role of SO<sub>2</sub> in the context of combined or  
28 complex exposures. While this will not be entirely novel to the current review, the notion  
29 that SO<sub>2</sub> might enhance response to other agents, or vice versa, remains important. Better  
30 appreciation of mechanisms that modulate response to pollutants (including innate  
31 immune/inflammatory mechanisms, antioxidant detoxification mechanisms) may provide  
32 insight into specific ways in which SO<sub>2</sub> might prime a person for increased response to  
33 another agent or vice versa.  
34
- 35 3. The impact of SO<sub>2</sub> on the mucociliary escalator is may be especially important in  
36 modifying response to PM  
37
- 38 4. Impacts of SO<sub>2</sub> on direct effects on cardiovascular disease, or in augmenting the impact of  
39 PM on CV disease will be important.  
40
- 41 5. Though not novel, impacts on persons with asthma will be important to assess  
42
- 43 6. Additionally, the increases in persons with other chronic metabolic diseases that are  
44 impacted by other pollutants (e.g. PM) suggest an additional focus in examining the effect

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1 of SO<sub>2</sub> in these populations. Obesity, diabetes, COPD, both elderly and the very young are  
2 all appropriate populations to assess with regard to respiratory and systemic impacts of SO<sub>2</sub>  
3

4 7. Additionally, increases in population BMI may change the impact of SO<sub>2</sub>. To the extent  
5 that increases in BMI modify dosimetry of SO<sub>2</sub>, this may change the pattern or tissue  
6 specificity of SO<sub>2</sub> exposure in these populations.  
7

8 8. Effects of SO<sub>2</sub> on response to biological agents found in many environments (both  
9

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

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**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.

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## Dr. Frank Speizer

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### ***Overall organization and clarity***

4 EPA has done an excellent job in describing the process to be used and the planned timeline to  
5 complete the work. As will be indicated below a major issue I believe not adequately address yet,  
6 but certainly hinted at, is the issue of the data base used to come up with the standard on the last  
7 review. Clearly the Administrator determined that not only would the standard be changed but that  
8 in the future more data were needed to reduce uncertainty in the selection of a 1 hour standard that  
9 would protect against 5-10 minute highs. My general concern is that EPA Staff may be  
10 underestimating the work load needed to address this issue with the potential added data obtained  
11 over the years.  
12

13

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

14 Overall the presentation is done well. Important points of the law are specified and particularly,  
15 although done as a footnote, the basic elements of *indicator, averaging time, form and level* are  
16 well defined.  
17

18

19 I think the Figure on Page 1-4 is important and although all the elements are present the “time  
20 flow” could be enhanced. It is well spelled out in the text; however, as presented the Figure looks  
21 as though CASAC and Public comment input are being simultaneously provided at all stages of the  
22 process and with the potential to go back to an earlier stage. It looks as though this is presented to  
23 save space on the page. More correctly the CASAC and public comment is really provided as one  
24 way arrows throughout the progression of the process and this would be better indicated by  
25 inserting the input along the path of the process rather than from the side.  
26

27

28 With regard to the Schedule, table 2.1 on page 2-2 suggests that there is a potential for an REA  
29 Planning Document not receiving more than a cursory review and not really being considered as a  
30 Draft. It is not clear if this means that EPA intends to use the previous REA on SO<sub>2</sub> as the  
31 document to be considered again, and I fear that EPA will not build in sufficient time for external  
32 review to have input. This is particularly of concern as we get to Chapter 5 where the discussion of  
33 the previous REA comes up and the suggestion is made that the basis of changing the standard in  
34 2009 was based on available 5 minute/1 hour data at that time. In my opinion this will have to be  
35 revisited in a serious way and this will need to be fully discussed when we get to the REA. Thus,  
36 indicating (“*if warranted*”) seems inappropriate.

37

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

38 All of the key questions appear to be considered. One of the key issues is to gather the new data  
39 that potentially has been obtained from one of the key mandates of the 2009 Administrator’s  
40 ruling. As indicated at the bottom of page 3-14 (and in section 1.3) for the first time EPA has  
41 required reporting from the states on 5 minute/1 hour concentrations. If this ruling has led to  
42 additional data this will be a critical activity to take place in this review. The previous conclusions  
43 on the relationship was based on limited data, yet was critical in making the jump to a new  
44 standard in terms of averaging time and level. EPA needs to budget sufficient time to revisit this

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1 arena as it will have the biggest impact on the potential for any change in the standard and their  
2 review will require evaluation by CASAC and public comment. It is not clear in Figure 3-1 on  
3 page 3-13 in the box labeled 'Consideration of Potential Alternative Standard(s)' that adequate  
4 description of what might be needed is included (again it is in the text).

#### 5 6 ***Science Assessment( Chapter 4)***

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

#### 16 17 ***Quantitative Risk and Exposure Assessment (Chapter 5)***

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

#### 33 34 ***Ambient Air Monitoring (Chapter 6)***

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

#### 40 41 ***Policy Assessment and Rulemaking (Chapter 7)***

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

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**Dr. Helen Suh**

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

4

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?*

10

11

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14

Chapter 5 is well-written, with a clear description of the REA scope and associated uncertainties. Table 5-2 is particularly helpful in illustrating the planned approach for future analyses. The new REA has the potential to dramatically improve estimates of risk and exposure from that conducted in the last review, given the addition of a large number of monitoring sites reporting 5-minute SO<sub>2</sub> concentrations. These new concentration data provide significant opportunities to address uncertainties identified in the previous REA, as has been noted in the IRP. In light of these potential gains, a new REA that incorporates the new 5-minute SO<sub>2</sub> data should be conducted.

21

22

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

23

*To what extent does Chapter 7 clearly summarize the general process for the policy assessment and rulemaking phase of this review?*

24

25

26

Chapter 7 provided a brief overview of the purpose and process for the policy assessment and rule-

27

making, which was clear and appropriate.

28



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## **Dr. James Ultman**

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

7

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

9

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

14

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

17

18

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

24

25 Chapter 2 is fine as written.

26

27

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

33

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

35

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

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

39

40

41 **Quantitative Risk and Exposure Assessment (Chapter 5):** Chapter 5 summarizes the key risk  
42 and exposure analyses from the last review, including associated uncertainties, and discusses our  
43 planned approach to considering the potential for additional analyses in the current review. To  
44 what extent does Chapter 5 clearly and adequately describe the scope and specific issues,

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1 including the identification of the most important uncertainties, to be considered in developing  
2 the REA Planning Document for this review? To what extent is there additional information that  
3 should be considered or additional issues that should be addressed in considering the potential  
4 for risk and/or exposure analyses in the current review?  
5

6 Generally speaking the chapter is well-written and quite detailed in the policy-relevant questions  
7 that will be addressed and the nature of improvements to the previous Sox REA that will be  
8 pursued.  
9

10 As in the previous review, the REA will utilize a three-prong approach consisting of an air quality,  
11 exposure, and quantitative health risk analyses. In the air quality and exposure analyses,  
12 benchmark exposures will be used as a means of framing the possible impact of health effects. In  
13 the introduction to section 5.1, the benchmark values used in the previous REA and the rationale  
14 for choosing them should be explicitly stated.  
15

16 The IRP mentions the distal shifting of SO<sub>2</sub> absorption with increased exercise levels because of  
17 increased ventilation and a switch from nasal to oral breathing (pg 4-13). This might have a  
18 substantial influence on lung dysfunction in children and workers that spend substantial time  
19 exercising outdoors. The current plan for the REA appears to consider moderate exercise only.  
20

21 I suggest that the new ISA include a section that integrates existing data on the exercise effect.  
22 Then, if it appears possible, the new REA should also strive to incorporate a ventilation effect into  
23 the exposure analysis and quantitative risk assessment.  
24

25 One minor comment: In section 5.1.1 that summarizes the key findings from the previous REA,  
26 the multiple levels of bulleted items are a bit confusing. Please try to rewrite this section so that  
27 there is only one level of bullets.  
28  
29

30 ***Ambient Air Monitoring (Chapter 6):*** To what extent does Chapter 6 clearly and appropriately  
31 communicate, for the purposes of this plan, the key aspects of measurement methods and  
32 surveillance network requirements for the SO<sub>2</sub> NAAQS?  
33

34 Only a minor comment: It is not clear how the 431 monitors mentioned on pg 6-2 (line 23) relates  
35 to the monitor numbers given in table 5.1.  
36  
37

38 ***Policy Assessment and Rulemaking (Chapter 7):*** To what extent does Chapter 7 clearly  
39 summarize the general process for the policy assessment and rulemaking phase of this review?  
40

41 This chapter is fine.  
42  
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## **Dr. Ronald Wyzga**

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

7

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

14

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

19

20

21

22