



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

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OFFICE OF  
THE ADMINISTRATOR

SUBJECT: CASAC Review and Closure of the Criteria Document for  
Sulfur Oxides/Particulate Matter

FROM: Sheldon K. Friedlander, Chairman *Sheldon K. Friedlander*  
Clean Air Scientific Advisory Committee (CASAC)

TO: Anne M. Gorsuch  
Administrator

On November 16, 1981, the Clean Air Scientific Advisory Committee of the Science Advisory Board completed its third review of the air quality criteria document for sulfur oxides/particulate matter (SOx/PM). The Committee notes with satisfaction the improvements made in the quality of the document during the course of previous CASAC reviews on August 20-22, 1980 and July 7-9, 1981. The staff of the Environmental Criteria and Assessment Office, directed by Dr. Lester Grant, have proven responsive to Committee advice as well as to comments provided by the general public, and deserve to be commended for the high quality of the document.

The purpose in writing you is to summarize the Committee's major conclusions to assist you in reviewing the scientific data and associated studies relevant to the establishment of revised ambient air quality standards for sulfur dioxide and particulate matter as required by law. This letter further advises you of the Committee's conclusion that the criteria document fulfills the requirements set forth in Section 108 of the Clean Air Act as amended, which requires that the document "shall accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare" from sulfur oxides and particulates in the ambient air.

The Committee is preparing a separate letter to you summarizing the conclusions of its reviews of the Draft Staff Paper for Particulate Matter. In addition, CASAC will prepare a similar report on the Draft Staff Paper for Sulfur Oxides once that document becomes available and its review is completed.

MAJOR SCIENTIFIC ISSUES AND CASAC CONCLUSIONS  
IN THE SO<sub>x</sub>/PM CRITERIA DOCUMENT REVIEW

Chapter 1: Executive Summary

In general, the revised draft Executive Summary critically synthesizes the key points of information discussed at length in the individual chapters. Its conclusions and interpretations of scientific data, studies, and issues are consistent with those presented in each chapter. Relationships among individual chapters are clearly defined; redundancies that do appear are reasonable given the complexity of the subject.

The quality of the Executive Summary would be further improved if more specific statements and/or tables were added to clarify certain important interrelationships. These include the differences in chemical composition associated with each of the several significant size ranges of particulate matter; and the health effects associated with the respiratory tract deposition patterns of particulate matter in the several size ranges and different chemical compositions. Quantitative health effects information useful in defining specific concentrations or ranges of concentrations of size-specific and/or chemical specific PM associated with the occurrence of health effects should also be highlighted. In view of evidence that total thoracic (tracheobronchial and alveolar) particle deposition is of public health concern, it would also be helpful to include a discussion of the likely equivalencies among British Smokeshade (BS), Total Suspended Particles (TSP), and

size selective particle aerometric measurements that would sample or index atmospheric concentrations of those sized particles identified with tracheobronchial or alveolar deposition.

#### Chapter 2: Physical and Chemical Properties of SO<sub>x</sub>/PM

This chapter is well written and addresses the important issues relevant to a criteria document. It presents a good summary of current knowledge of the factors affecting the physics and chemistry of sulfur dioxide and the pathways and kinetics of its transformation into sulfuric acid. It also provides a good summary of particle characteristics, dynamics, and hygroscopic growth.

#### Chapter 3: Techniques for the Collection and Analysis of SO<sub>x</sub>/PM

The revised chapter provides an excellent summary of the measurement of sulfur oxides and particulates. Especially important is the discussion of the capabilities of the various measurement techniques and the profile of pollutants in the ambient air which these measurements yield. The chapter correctly notes that British Smoke (BS), Coefficient of Haze (COHS), and Total Suspended Particulate (TSP) measurements do not adequately reflect key physical or chemical properties of particulate matter in the contemporary ambient air. Precise interconversion among units of BS, COHS, and TSP is not possible. In the context of a particulate standard, British Smoke is applicable only to a "sooty" smoke aerosol. It may not be a valid health effects indicator for the aerosol compositions observed in recent summertime episodes in the

United States and Europe. Thus, it is unlikely that BS can provide a sensitive index of hazard for today's air pollution.

#### Chapter 4: Sources and Emissions

Both natural and man-made sources emit sulfur dioxide and particulate matter into the ambient air. Given the limitations of our ability to derive reliable estimates from both types of sources, the criteria document presents an adequate discussion of current knowledge.

#### Chapter 5: Environmental Concentrations and Exposure

This chapter is largely acceptable in its present form. Most of the comments and suggestions which were made for previous drafts have been effectively incorporated. The most important omission from the chapter is information related to chemical composition with respect to particle size. Abundant information of this type is available for sulfates and some trace metals. Given the strong dependence of deposition rates and light scattering on particle size, it might have been worthwhile to refer to this literature in Chapter 5 or to direct attention to other document chapters (e.g., Chapter 2) where such relationships are discussed.

#### Chapter 6: Atmospheric Transport, Transformation and Deposition

This chapter is concise, well-written, and effective in communicating information related to the current status of mathematical models for air pollution. The utility of various models is clearly discussed, and the inadequacy of current models for quantitative extrapolation is pointed out. Topics which had been omitted from the

previous draft of this chapter have been added to other chapters with overlapping content. The chapter is now acceptable as written.

#### Chapter 7: Acidic Deposition

The Committee has recognized the desirability of incorporating existing information on acidic deposition in the present criteria document. Chapter 7 provides an abbreviated but adequate summary of the contribution of sulfur oxides and particulates to the formation, transport, and effects of acidic deposition. The Committee has concluded that Chapter 7 is a scientifically adequate summary with the conditional understanding that EPA is preparing a Critical Assessment Document for Acidic Deposition for its review that recognizes and incorporates information on causes, effects, and data bases for all of the various pollutants relevant to acidic deposition. CASAC has been briefed several times by Agency officials regarding the status of this document. The Committee looks forward to the submission of this integrated assessment for its critical review.

#### Chapter 8: Effects on Vegetation

In response to CASAC recommendations and public comments, this chapter on vegetation effects has been greatly improved compared to earlier drafts reviewed by the Committee. It now includes a more concise and interpretive critical evaluation of those few key studies yielding quantitative dose-effect or dose-response information of most use for criteria development and standard-setting purposes. It also

reasonably includes tables in the appendices which summarize studies of particulates and sulfur dioxide related vegetation effects that are of less utility for criteria development and standard setting.

The Committee concurs with Chapter 8 evaluations which point to the lack of dose-response data to establish quantitative evidence of deleterious effects on vegetation from particulates at presently encountered U.S. ambient air concentrations. In contrast to particulates, much clearer evidence exists by which to define quantitative exposure-effect relationships for sulfur dioxide effects on vegetation. Laboratory experiments in particular have demonstrated the greater relative toxicity to vegetation from high short-term exposures of sulfur dioxide. This is especially important in view of the fact that ambient air concentrations of sulfur dioxide from point sources often fluctuate widely and result in high intermittent short-term exposures of plants to sulfur dioxide concentrations against a background of longer-term but much lower annual average sulfur dioxide levels. Also of much importance are differences in the relative sensitivity of various plant species to sulfur dioxide exposures. The degree of sensitivity depends in part on factors such as phase of growth at time of exposure, ambient temperature and humidity levels, and plant water content. Among studies judged to be most useful for quantitative criteria development and standard setting are those of Dreisinger (1965, 1967) and Dreisinger and McGovern (1970) which demonstrate visible injury to white pine (a commercially important species in some U.S. areas) when natural stands of the tree in

southern Canada were exposed for 4 hours to 0.30 ppm or for 8 hours to 0.25 ppm sulfur dioxide emitted from a nearby smelter. Roughly similar exposure-effect relationships were observed in studies reported by Jones et al. (1974) and McLaughlin (1981) on the effects of sulfur dioxide from a southeastern U.S. power plant on a wide variety of natural species in the vicinity of the point source. In these studies some crop and garden species showed visible injury effects with 3 hour exposures to 0.6 - 0.8 ppm sulfur dioxide, while certain other crop species (potato, cotton, corn, peach) did not show visible injury at levels below 0.8 ppm. In contrast, a chamber study by Hill et al. (1974) suggests that plants common to the southwestern U.S., with markedly lower moisture content and under generally lower ambient air humidity levels, may be able to withstand much higher ambient sulfur dioxide concentrations (up to 11 ppm for two hours) without visible injury.

#### Chapter 9: Effects on Visibility and Climate

The technical aspects of this difficult problem are well characterized. The chapter does a good job of discussing the physics and public awareness of visibility. The relationship between fine particle mass concentrations and visibility has been well established. The criteria document thus provides an excellent technical basis for Agency decision-making on these issues.

#### Chapter 10: Effects on Materials

This chapter adequately discusses the currently available

scientific information concerning the effects of particulate matter and sulfur oxides on man-made materials. This includes critical assessments of available data concerning pertinent materials damage functions, uncertainties associated with existing characterizations of such functions, and limitations regarding estimation of monetary costs and/or benefits associated with the occurrence or control of such damage.

#### Chapter 11: Respiratory Deposition and Biological Fate of Inhaled Aerosols and Sulfur Dioxide

This chapter is very much improved compared to earlier drafts reviewed by CASAC and is now a comprehensive and more informative summary of existing knowledge relevant to a criteria document. The existing knowledge in this area is, in many cases, incomplete. For example, a potentially very important factor is the influence of the integrity of lung epithelial barriers (both airway and alveolar) on deposition and clearance. To enhance the chapter's comprehensiveness, this issue should be discussed more sufficiently in the criteria document, despite the paucity of available data.

#### Chapter 12: Toxicological Studies

This chapter is quite comprehensive as it describes essentially all toxicological studies relevant to a criteria document on sulfur oxides and particulates. Also, it provides commentary on

many studies and the significance of their findings to potential human health effects. In addition, the presentation of the information is more polished than the previous draft because of improved editing.

#### Chapter 13: Controlled Human Studies

This is a chapter which thoroughly discusses the published material on controlled human experiments. The scientific criteria for good studies discussed at the beginning of the chapter cannot be overemphasized. While not all studies meet these criteria, the Committee recognizes that EPA must take account of the available literature and believes the studies cited in the chapter have been appropriately selected and discussed. Overall the chapter is well-written and directed toward addressing those questions to which answers are needed. One of the most important criteria for good human clinical studies is that they be double-blind. Unfortunately, most of the studies in the literature were not so performed. This factor is especially significant when sensitive population groups, such as asthmatics, are under study.

The chapter is also improved by the discussion of exposures administered through the nose and mouth during controlled studies. It appropriately notes that caution should be used in any attempted extrapolation of observed quantitative exposure/effects resulting from such protocols, particularly when compared to results that might be expected under ambient exposure conditions. The chapter

identifies additional research results from studies using either face mask or open chamber oronasal breathing that would better resolve this issue, and it discusses existing studies in a balanced and thorough fashion.

#### Chapter 14: Epidemiological Studies

The current draft of this chapter represents considerable change and improvement over previous drafts reviewed by CASAC. Following discussion with the Committee, EPA has applied a set of guidelines for deciding which epidemiological studies are most appropriate for use in revising ambient air quality standards.

More specific comments on the chapter include the following:

1) the integration of Chapter 14 with Chapter 3 has advanced the "real world" understanding concerning the application of epidemiological methods; 2) the epidemiological studies providing the most useful quantitative concentration/response information for revising the 24-hour ambient particulate standard include: Lawther et al, 1958 and 1970; Martin and Bradley 1960; Martin 1964; Ware et al, 1981; and Mazumdar et al, 1981; 3) the epidemiological studies providing the most useful quantitative concentration/response information for revising the annual ambient particulate standard include: Ferris and Anderson 1962; Lunn et al, 1967; Ferris et al, 1971 and 1976; and Bouhuys et al, 1978; and 4) the studies by Lave and Seskin, 1970, and Mendelsohn and Orcutt, 1979 suggest an association between chronic exposure to high concentrations of

sulfates and increases in the level of mortality, but they do not indicate any threshold or safe level from such exposures, and they are not refined enough to provide estimates of the quantitative effect of sulfate concentrations on mortality.

#### Summary

The Committee made numerous comments of an editorial nature. These remarks, as well as a more detailed discussion of the recommendations and review provided above, are included in the transcripts of the three CASAC meetings held to review this document. With the understanding that the advised changes will be incorporated in the final criteria document, the Committee is satisfied that the air quality criteria document for sulfur oxides/particulate matter is scientifically adequate for use in standard setting.