ENVIRONMENTAL PROTECTION AGENCY

40 CFR Parts 50, 51, and 58

[AD-FRL 3243-8]

Proposed Decision Not To Revise the National Ambient Air Quality Standards for Sulfur Oxides (Sulfur Dioxide)

AGENCY: Environmental Protection Agency (EPA).

ACTION: Proposed rule.

SUMMARY: In accordance with sections 108 and 109 of the Clean Air Act (Act), EPA has reviewed and revised the criteria upon which the existing primary and secondary national ambient air quality standards (NAAQS) for sulfur oxides are based. The revised criteria document for sulfur oxides (and particulate matter) was issued on March 20, 1984 in conjunction with the proposed revisions to the particulate matter standards. EPA again updated and revised these criteria in an addendum to the revised criteria document, which was issued on July 1, 1987 in conjunction with the promulgation of revised particulate matter standards. The existing primary standards for sulfur oxides [measured as sulfur dioxide (SO_2)] are 0.14 parts per million (ppm) [365 micrograms per cubic meter ($\mu g/m^3$)], averaged over a period of 24 hours and not to be exceeded more than once per year, and 0.03 ppm (80 $\mu g/m^3$) annual arithmetic mean. The secondary standard is 0.5 ppm (1300 ($\mu g/m^3$), averaged over a period of 3 hours and not to be exceeded more than once per year.

As a result of its review and revision of the health and welfare criteria, EPA proposes not to revise these standards. The Administrator also solicits comment on an alternative of adding a 1-hour primary standard of 0.4 ppm. The promulgation of a 1-hour standard would also prompt consideration of additional revisions that would affect the remaining standards. If EPA promulgated a 1-hour standard, it would consider replacing the current secondary 3-hour standard (0.5 ppm) with a 1-hour secondary set equal to the primary standard. A second revision that would be considered is the adoption of an expected exceedance form for all of the standards. The Administrator is soliciting comments and analyses from the public on the merits of the proposed decision not to revise the current standards as compared to these alternative revisions. EPA also proposes to revise the significant harm levels, associated episode contingency plan guidance (40 CFR Part 51), and the Pollutant Standards Index for SO_2 (40 CFR Part 58). EPA is also proposing revisions to certain monitoring and reporting requirements (40 CFR Part 58).

DATES: EPA will hold a public hearing on this notice in approximately 45 days. The time and place will be announced in a subsequent **Federal Register** notice. Written comments on this proposal must be received by July 25, 1988.

ADDRESSES: Submit comments on the proposed action on the NAAQS (40 CFR Part 50) (duplicate copies are preferred) to: Central Docket Section (A-130), Environmental Protection Agency, Attn: Docket No. A-84-25, 401 M Street, SW., Washington, DC 20460. Comments on the proposed revisions to the monitoring and reporting requirements and Pollutant Standards Index (40 CFR Part 58) should be separated from those pertaining to the standards and sent to the same address, Attn: Docket No. A-87-06. Comments on the proposed revisions to the Significant Harm Level and episode criteria (40 CFR Part 51) also should be sent separately to the same address, Attn: Docket No. A-87-12. These dockets are located in the Central Docket Section of the U.S. Environmental Protection Agency, South Conference Center, Room 4, 401 M St., SW., Washington, DC. The docket may be inspected between 8:00 a.m. and 3:00 p.m. on weekdays, and a reasonable fee may be charged for copying. For the availability of related information, see **SUPPLEMENTARY INFORMATION.**

FOR FURTHER INFORMATION CONTACT: Mr. John Haines, Air Quality Management Division (MD-12), U.S. Environmental Protection Agency, Research Triangle Park, NC 27711, telephone (919) 541-5533 (FTS 629-5533).

SUPPLEMENTARY INFORMATION:

Availability of Related Information

The revised criteria document, Air Quality Criteria for Particulate Matter and Sulfur Oxides (three volumes, EPA-600/8-82-029af-cf, December 1982; Volume I, NTIS # PB-84-120401, $25.95 paper copy and $6.95 microfiche; Volume II, NTIS # PB-84-120419, $50.95 paper copy and $6.95 microfiche; Volume III, NTIS # PB-84-120427, $50.95 paper copy and $14.50 microfiche); the criteria document addendum, Second Addendum to Air Quality Criteria for Particulate Matter and Sulfur Oxides (1982): Assessment of Newly Available Health Effects Information (EPA/600/8-86-020-F, NTIS #PB-87-176574, $25.95 paper copy and $6.95 microfiche); the 1982 staff paper, Review of the National Ambient Air Quality Standards for Sulfur Oxides: Assessment of Scientific and Technical Information—OAQPS Staff Paper (EPA-450/5-82-007, November 1982; NTIS # PB-84-102920, $25.95 paper copy and $6.95 microfiche); and the staff paper addendum, Review of the National Ambient Air Quality Standards for Sulfur Oxides: Updated Assessment of Scientific and Technical Information (EPA-450/05-86-013, December 1986; NTIS # PB-87-200259, $14.95 paper copy and $6.95 microfiche) are available from: U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. (Add $3.00 handling charge per order.) A limited number of copies of other documents generated in connection with this standard review, such as the control techniques document, can be obtained from: U.S. Environmental Protection Agency Library (MD-35), Research Triangle Park, NC 27711, telephone (919) 541-2777 (FTS 629-2777). These and other related documents are also available in the EPA dockets identified above.

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I. Background

A. Legislative Requirements Affecting This Rule

1. The Standards

Two sections of the Act govern the establishment and revision of NAAQS. Section 108 (42 U.S.C. § 7408) directs the Administrator to identify pollutants which "may reasonably be anticipated to endanger public health or welfare" and to issue air quality criteria for them. These air quality criteria are to "reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of [a] pollutant in the ambient air * * *."

Section 109 (42 U.S.C. 7409) directs the Administrator to propose and promulgate "primary" and "secondary" NAAQS for pollutants identified under section 108. Section 109(b)(1) defines a primary standard as one "the attainment and maintenance of which, in the judgment of the Administrator, based on the criteria and allowing an adequate margin of safety, [is] requisite to protect the public health." A secondary standard, as defined in section 109(b)(2), must "specify a level of air quality the attainment and maintenance of which, in the judgment of the Administrator, based on [the] criteria, is requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of [the] pollutant in the ambient air." Welfare effects are defined in section 302(h) (42 U.S.C. 7602(h)) to include "effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being."

The U.S. Court of Appeals for the D.C. Circuit has held that the requirement for an adequate margin of safety for primary standards was intended to address uncertainties associated with inconclusive scientific and technical information available at the time of standard setting. It was also intended to provide a reasonable degree of protection against hazards that research has not yet identified. *Lead Industries Association v. EPA*, 647 F.2d 1130, 1154 (D.C. Cir. 1980), *cert. denied*, 101 S. Ct. 621 (1980); *American Petroleum Institute v. Costle*, 665 F.2d 1176, 1177 (D.C. Cir. 1981), *cert. denied*, 102 S. Ct. 1737 (1982). Both kinds of uncertainties are components of the risk associated with pollution at levels below those at which human health effects can be said to occur with reasonable scientific certainty. Thus, by selecting primary standards that provide an adequate margin of safety, the Administrator is seeking not only to prevent pollution levels that have been demonstrated to be harmful, but also to prevent lower pollutant levels that he finds pose an unacceptable risk of harm, even if that risk is not precisely identified as to nature or degree.

In selecting a margin of safety, EPA has considered such factors as the nature and severity of the health effects involved, the size of the sensitive population(s) at risk, and the kind and degree of the uncertainties that must be addressed. Given that the "margin of safety" requirement by definition only comes into play where no conclusive showing of harm exists, such factors, which involve unknown or only partially quantified risks, have their inherent limits as guides to action. The selection of any particular approach to providing an adequate margin of safety is a policy choice left specifically to the Administrator's judgment (*Lead Industries Association v. EPA, supra*, 647 F.2d at 1161–62).

Section 109(d) of the Act (42 U.S.C. 7409(d)) requires periodic review and, if appropriate, revision of existing criteria and standards. The process by which EPA has reviewed the original criteria and standards for sulfur oxides under section 109(d) is described in a later section of this notice.

2. Related Control Requirements

States are primarily responsible for ensuring attainment and maintenance of ambient air quality standards once EPA has established them. Under section 110 of the Act (42 U.S.C. 7410), States are to submit, for EPA approval, State implementation plans (SIP's) that provide for the attainment and maintenance of such standards through control programs directed to sources of the pollutants involved. The States, in conjunction with EPA, also administer the Prevention of Significant Deterioration Program (42 U.S.C. 7470–7479) for these pollutants. In addition, Federal programs provide for nationwide reductions in emissions of these and other air pollutants through the Federal Motor Vehicle Control Program under Title II of the Act (42 U.S.C. 7521–7574), which involves controls for automobile, truck, bus, motorcycle, and aircraft emissions; the New Source Performance Standards under section 111 (42 U.S.C. 7411); and the National Emission Standards for Hazardous Air Pollutants under section 112 (42 U.S.C. 7412).

B. Sulfur Oxides and Existing Standards for SO_2

The principal focus of this standard review is on the health and welfare effects of SO_2, alone and in combination with other pollutants. Other sulfur oxide vapors (e.g., SO_3) are not commonly found in the atmosphere. Information on the effects of the principal atmospheric transformation products of SO_2 (i.e., sulfuric acid and sulfates) was considered in the review of the particulate matter standards and addressed in the revisions to these standards promulgated on July 1, 1987 (52 FR 24634); acid sulfate aerosols are also being examined in a separate issue paper that is currently under development (Thomas, 1986).

SO_2 is a rapidly diffusing reactive gas that is very soluble in water. It is emitted principally from combustion or processing of sulfur-containing fossil fuels and ores. SO_2 occurs in the atmosphere with a variety of particles and other gases, and undergoes chemical and physical interactions with them forming sulfates and other transformation products. At elevated concentrations, SO_2 can adversely affect human health, vegetation, materials, economic values, and personal comfort and well-being. SO_2, largely through its transformation products, also is a major contributor to pollutants related to acidic deposition and visibility degradation. Annual average SO_2 levels

range from less than 0.004 ppm in remote rural sites to over 0.03 ppm in the most polluted urban industrial areas. The highest short-term values are found in the vicinity (< 20 km) of major point sources. In the absence of adequate controls, maximum short-term levels at such sites for 24-hour, 3-hour, and 1-hour averages can reach or exceed 0.4 ppm, 1.4 ppm, and 2.3 ppm, respectively. The origins, concentrations and potential effects of SO_2 are discussed in more detail in the staff paper (SP) (EPA, 1982a), in the revised criteria document (CD) (EPA, 1982b), in the criteria document addendum (CDA) (EPA, 1986a), and the staff paper addendum (SPA) (EPA, 1986e). The executive summary of the SPA is reprinted in Addendum III to this notice.

On April 30, 1971, EPA promulgated primary and secondary NAAQS for SO_2 under section 109 of the Act (36 FR 8186). The existing primary standards for sulfur oxides, measured as SO_2, are 0.14 ppm (365 $\mu g/m^3$), averaged over a period of 24 hours and not to be exceeded more than once per year, and 0.03 ppm (80 $\mu g/m^3$) annual arithmetic mean. The current secondary standard is 0.5 ppm (1300 $\mu g/m^3$), averaged over a period of 3 hours and not to be exceed more than once per year. An annual secondary standard was revoked by EPA in 1973 after court remand. The scientific and technical bases for the current standards are contained in the original criteria document, Air Quality Criteria for Sulfur Oxides (DHEW, 1970) and the revised chapter on vegetation (EPA, 1973).

Implementation of SO_2 air quality standards by the States and EPA, together with fuel use shifts and siting decisions motivated by changing economic conditions, has resulted in substantial improvements in ground level air quality and significant reductions in nationwide emissions over the last decade. Where sufficient trends data existed, annual SO_2 concentrations at urban sites decreased by 30 percent from 1970 to 1975 (EPA, 1976). From 1975 to 1984, annual levels dropped an additional 36 percent and maximum 24-hour values declined by an even larger percentage (EPA, 1986d). Over this same time period (1975–1984), national SO_2 emissions declined by an estimated 16 percent (EPA, 1984a). Today, SO_2 air quality is good with respect to the standards, with only a small fraction (2 percent) of the nation's counties designated as nonattainment for SO_2. Moreover, in most cases, the nonattainment designations apply only to limited geographical areas in the immediate vicinity of certain major point sources.

C. Development of Revised Air Quality Criteria for Sulfur Oxides

In 1976, as a result of internal Agency review and the recommendations of a committee on EPA's Science Advisory Board, EPA decided to revise the existing criteria document for sulfur oxides. Because of competing priorities regarding revision of other air quality criteria documents, and the need to complete additional research on sulfur oxides and their transformation products, the process was scheduled to commence in 1979. With the endorsement of the new Clean Air Scientific Advisory Committee (CASAC) of EPA's Science Advisory Board, EPA decided in 1978 to review and revise the criteria document for sulfur oxides concurrently with that for particulate matter and to produce a combined particulate matter/sulfur oxides (PM/SO_x) criteria document.

On October 2, 1979 (44 FR 56731), EPA announced that it was in the process of revising the original criteria document for sulfur oxides and reviewing the existing air quality standards for possible revisions in accordance with section 109(d)(1) of the Act.

In developing the revised criteria document, EPA has provided a number of opportunities for review and comment by organizations and individuals outside the Agency. Three drafts of the revised PM/SO_x criteria document, prepared by EPA's Environmental Criteria and Assessment Office (ECAO), have been made available for external review (45 FR 24913, April 11, 1980; 46 FR 9746, January 29, 1981; 46 FR 53210, October 28, 1981). EPA has received and considered numerous and often extensive comments on each of these drafts. CASAC has held three public meetings (August 20–22, 1980; July 7–9, 1981; November 16–18, 1981) to review successive drafts of the document. These meetings were open to the public and were attended by many individuals and representatives of organizations who provided critical reviews and new information for consideration. Transcripts of the CASAC meetings have been placed in the docket for the criteria document (ECAO CD 79–1). Based on CASAC recommendations made after the first review meeting, five additional public workshops were held at which EPA, its consulting authors and reviewers, and other scientifically and technically qualified experts selected by EPA discussed the various chapters of the draft document and suggested ways of resolving outstanding issues (45 FR 74047, November 7, 1980; 45 FR 76790, November 20, 1980; 45 FR 78224, November 25, 1980; 45 FR 80350, December 4, 1980; 46 FR 1775, January 17, 1981).

The comments received on the successive drafts of the revised criteria document have been considered in the preparation of the final document, issued March 20, 1984, with the proposed revisions to the ambient air quality standards for particulate matter (49 FR 10408). In accordance with its established procedures, CASAC prepared a "closure" memorandum to the Administrator that indicated the Committee's satisfaction with the final draft (December 1981) of the criteria document and outlined key issues and recommendations. The closure memorandum, dated January 29, 1982, stated that the EPA office that prepared this document was "responsive to Committee advice as well as to comments provided by the general public * * *." The closure memorandum further states that the criteria document "fulfills the requirements set forth in section 108 of the Clean Air Act, which requires that the criteria 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 CASAC closure memorandum on the criteria domument is reprinted in its entirety in Addendum I to this notice.

Following closure, a number of minor technical and editorial refinements were made to prepare the criteria document for final publication. During this process several scientific articles were published, or accepted for publication, that appeared to be of some importance to the development of criteria for the primary standards for SO_2. For this reason, ECAO prepared an addendum to the criteria document that summarized and evaluated the newly available studies and their implications for the review and conclusions in Chapter 13 of the criteria document. Two drafts of the addendum were reviewed by CASAC and the public in association with two public meetings (April 26–27, 1982; August 30–31, 1982). Transcripts of these meetings have been placed in the docket. Oral closure on the addendum was received from CASAC at the August meeting and the final product was included as Appendix A to Volume I of the criteria document (EPA, 1982b) when the document was published on March 20, 1984.

A number of scientific and technical issues were raised during the public review of the scientific criteria. With respect to the sulfur oxides portions of

the criteria document, the major issues included: (1) The interpretation of controlled human studies of asthmatics and other subjects using differing means to administer SO_2 at various exercise rates, and (2) the development and application of criteria for deciding which epidemiological studies are most appropriate for use in revising air quality standards. A summary of these and other major scientific issues, as well as CASAC's conclusions, is included in the closure memorandum on the criteria document (Addendum I to this notice).

D. Review of the Standards: Development of Staff Paper

In the spring of 1982, EPA's Office of Air Quality Planning and Standards (OAQPS) prepared the first draft of a staff paper, Review of the National Ambient Air Quality Standards for Sulfur Oxides. This draft staff paper evaluated and interpreted the scientific and technical information in the revised criteria document and the then-draft addendum that was most relevant to the review of the air quality standards for sulfur oxides and presented staff recommendations on alternative approaches to deciding whether, and if so how, to revise the standards, based on the revised criteria document and the then-draft addendum. This first draft and a second draft of the staff paper were reviewed at CASAC meetings on April 26–27 (47 FR 16885), and August 30–31, 1982 (47 FR 34855), respectively. Transcripts of these meetings have been placed in the docket. Numerous written and oral comments were received on the drafts from CASAC, representatives of organizations, individual scientists, and other interested members of the public. A summary of major revisions made in response to comments on the first draft is contained in an August 5, 1982 letter to CASAC (Padgett, 1982). Following the second CASAC meeting, the staff made some additional revisions in response to comments. EPA released the final OAQPS staff paper (EPA, 1982a), which reflects the various suggestions made by CASAC and members of the public, upon receipt of the formal closure letter in August 1983. The August 26, 1983 CASAC closure letter states that the staff paper is consistent with the criteria document, and provides the Administrator "with the kind and amount of technical guidance that will be needed to make appropriate decisions about revisions to the standard" (the CASAC letter is reprinted in Addendum II to this notice).

A number of major issues were raised during the public review process. The most important issue involved the question of whether the results of relatively recent controlled human studies indicate the need for a new short-term (1-hour) standard for SO_2 to protect asthmatics. Some groups strongly favored the addition of a 1-hour standard while others felt that the current standards provide adequate protection of sensitive groups. Some attention was also focused on the extent to which the effects of SO_2 can be separated from those of particulate matter in key epidemiological studies, and on whether welfare criteria warrant a secondary annual SO_2 standard in addition to, or in place of, the existing primary annual standard.

These and other major issues are discussed more fully in the executive summary of the staff paper and in later sections of this notice. CASAC's discussion of these issues and its recommendations are contained in the Committee's closure letter on the staff paper (Goldstein, 1983) and in a minority statement from one member (Higgins, 1983). Both letters are reprinted in Addendum II to this proposal.

In 1984, the Administrator reviewed the standards in light of the above information and decided, at that time, not to propose any revision of the standards.

E. Supplemental Criteria Revision and Standards Review

Following CASAC closure on the criteria document and its addendum in 1982, numerous additional studies on the health effects of SO_2 appeared in the scientific literature. Because some of these studies could be of importance in a decision on the SO_2 standards and because of CASAC recommendations regarding new particulate matter studies (Lippmann, 1986a), EPA decided to prepare addenda to the PM/SO_x criteria document and the SO_2 staff paper (51 FR 11058, April 1, 1986). On July 3, 1986, EPA announced (51 FR 24392) the availability of an external review draft document entitled: Second Addendum to Air Quality Criteria for Particulate Matter and Sulfur Oxides (1982): Assessment of Newly Available Health Effects Information. On September 16, 1986, EPA announced (51 FR 32878) the availability of a draft staff paper addendum entitled: Review of the National Ambient Air Quality Standards for Sulfur Oxides: Updated Assessment of Scientific and Technical Information. CASAC held a public meeting on October 15–16, 1986 to review both the criteria document addendum and the staff paper addendum. At this meeting, CASAC members as well as representatives of several organizations provided critical review of both EPA documents. A transcript of the CASAC meeting has been placed in the public docket (A–82–37).

The CASAC sent a closure letter on the criteria document addendum to the Administrator dated December 15, 1986, which concludes that "this 1986 Addendum along with the 1982 Criteria Document, previously reviewed by CASAC, represent a scientifically balanced and defensible summary of the extensive scientific literature on these pollutants" (Lippmann, 1986b). This letter is reprinted in Addendum I to this Notice. The Committee sent its closure letter, dated February 1987, on the staff paper addendum to the Administrator stating "The Committee believes that this document provides you with the kind and amount of technical guidance that will be needed to make appropriate decisions on the standards" (Lippmann, 1987). The closure letter on the staff paper addendum, which also discusses major issues addressed by the CASAC and the Committee's recommendations concerning these issues, is reprinted in Addendum II to this notice. The final addenda to the criteria document (EPA, 1986a) and the staff paper (EPA, 1986e), which include revisions to reflect comments from CASAC and the public, are available from the address listed above. Where there are differences between the 1982 criteria document and staff paper and the more recent addenda, the addenda supersede the earlier documents. The executive summary of the staff paper addendum is reprinted in Addendum III to this notice.

F. Rulemaking Docket

EPA established a standard review docket for the sulfur oxides revision in July 1979. EPA has established a rulemaking docket (Docket No. A–84–25) for this proposal as required by section 307(d) of the Act. The standard review docket (Docket No. A–79–28) and the separate docket established for criteria document revision (Docket No. ECAO–CD–79–1) have been incorporated in this rulemaking docket.

II. Rationale for the Proposed Decision Not To Review the Standards

Based on the comprehensive examination of all available scientific information on the health and welfare effects of sulfur oxides in the criteria document and on certain analyses of current and alternative standards, the EPA staff and CASAC recommended that the Administrator focus consideration on a discrete range of scientifically supportable policy options for revising or not revising the SO_2 standards. The Administration has relied heavily on these

recommendations, and on the detailed rationale contained in the SP and SPA and CASAC closure letters (Goldstein, 1983; Lippmann, 1987) in reaching his decision to propose not to revise the current standards. Rather than restating those evaluations and supporting reasons leading to the recommendations at length, the following discussion of the proposed decision focuses primarily on those considerations that were most influential in the Administrator's decision, or that add to or differ in some respect from considerations that influenced the staff and/or CASAC recommendations.

Taken one at a time, the staff and CASAC recommendations could have led to many potential combinations of retaining, modifying, and adding to the current standards. The Administrator focused mainly on determining whether to leave the current standards in their present form or to add a new 1-hour primary standard and, in the process, consider some additional revisions to the remaining standards. In today's notice, the Administrator proposes not to revise the current standards but calls for comment on the alternative of adding a 1-hour standard. The key elements and principal bases for this decision are summarized below.

A. Basis for the Current Standards

Both the staff and CASAC recommended that serious consideration be given to not revising the current standards (SP, pp. 86–87; Goldstein, 1983). The scientific data provide support for retaining each of the present standards. Analyses of the protection afforded by single and multiple SO_2 standards against effects associated with various averaging times suggest that continued implementation of all three current primary and secondary standards provides substantial protection against the direct health and welfare effects identified in the criteria document as being associated with ground level SO_2 air quality (SP, pp. 79–83; Appendix D). The major bases for each of the current standards are presented more fully below. The rationale for retaining the current averaging convention and form for the standards is discussed in subsequent sections (IIC, D).

1. 24-Hour Primary Standard

The basis for a 24-hour health standard stems largely from epidemiological studies conducted in London in the 1950's and 1960's, a time when both SO_2 and particulate matter were present at higher concentrations than in the U.S. under current conditions. The principal effects associated with high 24-hour levels of SO_2, which in these studies usually also involved high levels of particulate matter, include increased daily mortality and aggravation of bronchitis. More recent studies also suggest the possibility of decreased lung function. The staff assessment of these studies is summarized in Table 2 of Addendum III to this notice and discussed more fully in the SP (SP, pp. 71–88) and the SPA (SPA, pp. 22–29). As indicated there, these studies taken together do not suggest any clear threshold for all effects. They do, however, provide evidence for increasing risks to public health as 24-hour SO_2 averages increase. Based on its review, the staff recommended retention of a 24-hour standard in the range of 0.14 to 0.19 ppm (SP, p. 85, and SPA, p. 59–60). The CASAC concluded that the upper end of the range provides little or no margin of safety for sensitive populations, and recommended selection of a value in the lower portion of the range (SP, Appendix E, p. 4). The staff and CASAC identified the following as factors to be considered in selecting a level for a 24-hour standard that provides an adequate margin of safety (SP, pp. 75–78):

a. possible interactive effects with other pollutants;

b. differences among conditions observed in the earlier studies (London in the 1950's and 1960's) and those that occur in the contemporary U.S.;

c. suggestion of risk of other effects (e.g., reduced lung function, effects on clearance) from qualitative studies; and

d. the possibility that the observed effects may be related, in part, to shorter-term peaks.

In view of the above considerations and recommendations, the Administrator finds that the current 24-hour standard provides an adequate margin of safety against the effects observed in the more quantitative 24-hour epidemiological studies. The margin of safety is sufficient even where SO_2 and particulate matter concentrations both occur simultaneously at their respective standard levels, and is greater when particle levels are lower (SP, p. 75). Although qualitative inferences from the available scientific evidence suggest some risk of 24-hour effects not identified in the more quantitative studies, current assessments suggest such risks would be small at concentrations at or below the present standard level (SP, pp. 76–78). Retaining the current standard is consistent with CASAC guidance to select any revised standard from the lower portion of the staff range of interest and to maintain the margin of safety provided by the current standard in the absence of a 1-hour standard (Goldstein, 1983; Lippmann, 1987).

2. Annual Primary Standard

The available scientific data provide some qualitative support for the concern that high annual SO_2 exposures may lead to potential effects not readily observed in short-term human studies, for example reduced capacity to respond to infection or other environmental challenges (SP, 78–79). While no single study may provide clear quantitative conclusions, the staff found that there does appear to be some consistency across the results of more recent epidemiological studies indicating a possibility of respiratory health effects as a result of persistent exposures to sulfur oxides in areas with long-term averages only slightly above the current standards (SPA, p. 50); the data are, however, unclear as to whether repeated short-term peaks of SO_2 or other pollutants (e.g., PM) may be as or more responsible for such effects (SPA, p. 32). Staff analyses conducted at CASAC's request indicated that alternative shorter-term standards (1, 3, and 24-hour) would not necessarily prevent increases in annual SO_2 concentrations to levels above the current standard (0.03 ppm) in several heavily populated urban areas (SP, Appendix D). The long-term standard often serves to limit the emissions and resulting acute and chronic exposures from numerous smaller sources in such areas. Based on concern over the potential effects of a large increase in both chronic and acute population exposures if the annual standard were relaxed or eliminated, the staff recommended that the Administrator retain the annual SO_2 primary standard at its current level (SP, p. 79; SPA, p. xi).

CASAC agreed that there is a need for protection against an increase in chronic exposures (Goldstein, 1983), but found little quantitative support in the scientific literature on chronic effects for retaining the present annual primary standard (Lippmann, 1987). CASAC also recommended that the decision on the annual standard be considered in "light of the total protection that is to be offered by the suite of standards * * *." In a related recommendation, the Committee indicated that the most persuasive scientific basis for an annual standard was found in the potential welfare effects that could result from increased annual SO_2 concentrations. The staff assessment of the welfare effects of ambient SO_2 indicated that the major effects of concern were damage to

materials (SP, pp. 123–124) and vegetation (SP, pp. 113–114). CASAC concurred with corresponding staff recommendations regarding protection of welfare and concluded that "there is a scientific basis for a secondary standard at the level of the annual primary standard."

The Administrator finds that retaining an annual primary standard at the current level is a prudent public health policy choice that will limit any increase in acute or chronic health risk in large, populated urban areas that are now attaining the standard. Although the available information suggests that the magnitude of any such health risk to individuals is probably small, the concern that a large number of people might experience increased chronic and acute exposures supports continuation of some level of protection against the aforementioned hazards not yet conclusively established in the scientific literature (SP, p. 78–79; SPA, p. 50). In addition, the Administrator agrees with staff conclusions that without the current annual primary standard, a new annual secondary standard might be necessary to protect public welfare. Given the available welfare effects data with respect to long-term SO_2 concentrations, retaining the level of the current annual standard would appear to be appropriate. From this standpoint, removal or substantial relaxation of the annual primary standard would necessitate its replacement by an annual secondary standard.

With the continued concerns over chronic health effects—whether from long-term low level or repeated peak exposures—and CASAC's recommendation to continue the welfare protection afforded by the current standard, the Administrator proposes to retain the level of health and welfare protection afforded by the current annual primary standard. Because that standard is attained virtually everywhere, the Administrator is not persuaded that there would be any practical benefits to be gained from the administrative disruptions associated with adding an equivalent annual secondary standard and/or revising the form or level of this primary standard.

3. 3-Hour Secondary Standard

The basis for the existing 3-hour secondary standard rests on studies documenting acute effects on sensitive plants (38 FR 25678; September 1973). The effects of concern include reduced growth and yield, and foliar injury. The staff assessment of the greatly expanded scientific data base as summarized in the criteria document (CD, Chapter 7) found even stronger support for the 3-hour standard (SP, pp. 108–112). As a result of this most recent review, both staff and CASAC recommended retaining a 3-hour standard at or slightly bleow the level of the current standard (0.5 ppm) (SP, p. 126). CASAC pointed out that evidence suggesting effects at lower levels is very uncertain (SP, Appendix E, p. 8). Moreover, as pointed out in the SP, the extent of exposure of both cultivated and natural vegetation to levels capable of producing injury or reducing yield is limited (SP, p. 109). Peak short-term exposures of concern occur only in the vicinity of major point sources. The extent of vegetation at risk is further reduced because natural systems in less humid areas appear to be less sensitive to SO_2 than cultivated plants (SP, p. 112). These factors suggest that the current standard level is adequate. Considering the assessment of effects on vegetation and the above conclusions and recommendations, the Administrator finds that the current 3-hour standard appears to be both necessary and adequate to protect against damage to vegetation from short-term SO_2 peaks near major point sources. Retaining the current 3-hour standard is consistent with staff and CASAC recommendations.

B. Consideration of Short-Term (1-Hour) Primary Standard

As discussed above, the assessment of available scientific evidence and recommendations of staff and CASAC have led the Administrator to conclude that the current primary and secondary SO_2 standards are adequate to protect the public health and welfare from the effects associated with 24-hour, annual, and 3-hour average concentrations of SO_2 in the atmosphere. This recent assessment of the scientific literature included a review of the potential effects on asthmatics and other sensitive individuals associated with short-term (1-hour or less) exposures to SO_2. While the Administrator is inclined to conclude that this information does not warrant setting a new short-term primary standard, there has been considerable discussion on whether such a standard is needed to protect against such exposures. For reasons outlined in the staff assessment (SP, p. 56), 1-hour is an appropriate averaging time to consider for such a possible new standard. The discussion below summarizes the basis for such consideration and assesses the protection afforded by the present standards against short-term exposures.

1. Short-Term Health Effects

The basis for considering the possible addition of a new 1-hour standard rests largely on the staff and CASAC assessment of the results of several relatively recent controlled human exposure studies (see Table 1 of Addendum III to this preamble). The major effects observed in these studies are measurable changes in respiratory function in asthmatics and atopics [1] exposed for short periods (as little as 5–10 minutes up to 1-hour) to 0.4 ppm SO_2 or more. For example, in one study designed to examine this issue, a concentration of 0.5 ppm for 10 minutes produced a doubling (or more) in airway resistance in 25 percent of exercising asthmatic subjects (Horstman et al., 1986). The responses occurred predominantly in subjects whose respiratory ventilation was increased by exercise or by hyperventilation, and who were not using preventive medication at the time (SPA, pp. 9–10; CDA, Table 5; Sheppard et al., 1981). In asthmatic subjects exposed to 0.4–0.75 ppm or more of SO_2, the change in respiratory function was often accompanied by perceptible symptomatic responses, including shortness of breath, wheezing and coughing (SPA, Table 4–1). The fraction of asthmatic subjects experiencing changes in lung function and symptoms increased with concentration over the range of 0.4 to 0.75 ppm (SPA, Figure 3–2).

While mindful of the guidance in the criteria document that "caution should be employed in regard to any attempted extrapolation of these observed quantitative exposure-effect relationships to what might be expected under ambient conditions" (CD, p. 13–50), the staff and CASAC concluded that consideration should be given to a new short-term standard to address these effects. Based on practical considerations relating to monitoring, modeling, data manipulation and storage, and implementation, the staff recommended using a 1-hour averaging time for any such standard. As explained below, the relationship between 1-hour average concentrations and shorter-term concentrations would allow the use of a 1-hour standard, set at an appropriate level, to control shorter-term peaks. Staff and CASAC identified a number of factors that should be considered in decisionmaking

[1] "Atopic" is a term used to indicate individuals, not diagnosed as asthmatics, with disorders manifested as hypersensitivity to environmental antigens. Examples include hay fever and other allergies. Approximately 8 percent of the U.S. population is estimated to be atopic. Some additional percentage of the population not diagnosed as atopic or asthmatic may also display hyperreactive airway responses to SO_2 (SP, p. 30).

concerning a 1-hour standard (SP, pp. 64–69; SPA, pp. 37–44):

a. Significance of Effects. The functional changes and symptoms observed in the controlled studies appear to be transient and reversible, and, at lower concentrations (<0.75 ppm) and exercise levels, they are within the range of day-to-day variations that most asthmatics typically experience from exercise or other stimuli. They are, in general, not equivalent to the more severe responses that accompany an asthma "attack" (SP, p. 66). Finally, because medications already widely used by asthmatics can prevent (Sheppard et al., 1981) or ameliorate reaction to SO_2, an asthmatic who is already medicated due to other stimuli will likely not experience a response to an exposure. The scientific community is divided as to whether and to what extent these effects at lower concentrations should be considered "adverse" or "clinically significant" (e.g., Boushey, 1981; Higgins, 1983; Cohen, 1984; McFadden, 1986; Lippmann, 1987; see also SPA, pp. 40–41).

b. Relative Effect of SO_2 Compared to Other Stimuli. Exercise alone, without pollutant exposure, is among a number of stimuli that commonly induce bronchoconstriction in asthmatics (SP, pp. 66–67). Cold and/or dry air exacerbates the effects of exercise even in the absence of SO_2. It is likely that the incidence of bronchoconstriction induced by SO_2 is very small compared with that induced by factors unrelated to pollution (Cohen, 1984 and EPA, 1986c).

c. Sensitive Population. Diagnosed asthmatics make up approximately 4 percent of the total U.S. population (about 10 million individuals) while atopics constitute roughly 8 percent (SP, p. 31). Some additional percentage of the population not diagnosed as atopic or asthmatic may also display hyperreactive airway responses to SO_2 (SP, p. 30). Asthmatics appear to be at greater risk than atopics. Studies to date have shown a wide distribution of sensitivity among asthmatics and atopics tested (e.g., Horstman et al., 1986). Although it is speculated that individuals with more severe asthma may be more sensitive to SO_2 than are the relatively mild asthmatics tested, CASAC has pointed out that the available data do not support or refute this point (Lippmann, 1987). The consequences of a functional change are of greater concern in more severe asthmatics, but such individuals may be somewhat protected from SO_2 because they routinely use medication due to their susceptibility to responses from other stimuli and the reduced chance that they would experience sustained levels of moderate to high exercise (SPA, p. 40).

d. Variance About the 1-hour Average. The available studies indicate that SO_2 effects occur within 5 to 10 minutes but do not necessarily worsen with continued exposure over an hour (CDA, pp. 4–29 to 4–32). Concentrations averaged over 5 or 10 minutes vary about the 1-hour mean, reaching peak values that are clearly higher than the 1-hour value. Analyses of recent data indicate that at higher concentrations near large point sources, these peaks are likely to be within a factor of 2 of the mean. Thus, the maximum 5 to 10 minute peak associated with a 1-hour value of 0.5 ppm is probably less than 1 ppm (SPA, p. 43–44).

e. Probability of Exposure. The staff assessment found that, given current air quality levels, peak SO_2 concentrations in the 0.4 to 0.75 ppm range for 5 to 10 minutes are very infrequent and limited in extent to the vicinity of certain large sources. Given low indoor levels and the limited time individuals spend in moderate to high activity, the probability that any individual asthmatic would experience any effects of SO_2 is low (SP, p. D–12; EPA, 1986c). This issue has been examined in the quantitative analyses discussed in the following section.

2. Protection Afforded by Current Standards Against Short-Term Effects

In determining whether to revise the present standards by the addition of a 1-hour primary standard, it is particularly important to evaluate: (1) The extent to which implementation of the current standards protects against potential very short-term effects, and (2) the relative increase in protection that would be afforded by the addition of a possible 1-hour primary standard. The first point is addressed in this section, while the second point is addressed in the following section.

(a) Air Quality and Exposure Analyses. The initial staff examination of the above issues focused on monitoring [2] and modeling analyses of 1-hour SO_2 concentrations (SP, Appendix D). The initial modeling analyses predicted the frequency of 1-hour exceedances of 0.5 ppm that would occur around typical major point sources if the current standards are met. This concentration (0.5 ppm) was the lowest short-term (5-minute to 1-hour) level found to produce changes in respiratory function and symptoms in the controlled studies of exercising "mild" asthmatics included in the 1982 staff paper. Because the then-available dispersion models were limited to 1-hour predictions, estimates of 5- to 10-minute exceedances of 0.5 ppm were not included. The key findings of the preliminary analyses were:

1. Given current U.S. air quality, peak 1-hour SO_2 concentrations greater than or equal to 0.5 ppm occur almost exclusively around large point sources and are rare near the population-oriented monitoring sites studied (SPA, p. 42).

2. Near major point sources in urban and suburban locations, the current 24-hour standard provides substantial control of peak concentrations, limiting estimated 1-hour exceedances of 0.5 ppm at any single site to 9 hours per year or less (Stoeckenius and Burton, 1982, p. 9).

3. Near point sources located in nonurban areas, the current 3-hour secondary standard is estimated to reduce the number of hours exceeding 0.5 ppm at any single site to 3 to 4 hours per year (Burton et al., 1982, p. v.).

4. Based on these air quality findings and qualitative information on human activity patterns, the staff concluded that the probability that an exercising asthmatic would be located in the same time and area with peak levels of concern appeared small (SP, p. 68).

Following completion of the formal CASAC review of the criteria document and staff paper, EPA staff conducted a series of additional analyses that expanded or improved on the work summarized above to better characterize the protection afforded by the current SO_2 standards and to identify any improvements that would be offered by adding alternative standards. These supplemental analyses are described in detail in separate reports (EPA, 1984a; 1986b,c), copies of which have been placed in the docket. These analyses were summarized in the staff paper addendum (pp. 50–58) and were provided to CASAC for review.

These analyses involved: (1) Expansion of the previous analysis of monitoring data and air quality modeling to include more sources and locations as well as shorter averaging

[2] The monitoring-based analysis examined approximately 900 SO_2 monitoring sites representing 11 million hours of data (SP, Appendix D). Those sites were classified in three groups: (1) Population-oriented sites include those established to be representative of concentrations experienced in populated areas; (2) source-oriented sites located to record maximum concentrations near sources such as power plants and refineries; and (3) smelter-oriented sites located near this specific source category.

periods, and (2) quantitative estimates of exposures of sensitive asthmatics to peak concentration of potential concern.[3] Because studies had shown pulmonary function changes and symptoms in some asthmatics exposed while at exercise to 0.5 ppm for periods as short as 5 to 10 minutes the air quality data and modeling analyses dealt with 5-to 10-minute as well as 1-hour peak concentrations in excess of 0.5 ppm. These analyses provided estimates of the frequency and geographical extent of such exceedances in the vicinity of four power plants judged to be fairly representative of the expected spectrum of exposure scenarios. Exposures were estimated for current emissions, and for emissions that just meet the current standards as well as alternative revised standards. Beginning with the results of modeled peak SO_2 levels, a variant of the National Exposure Model (NEM) was applied to estimate the probability that an asthmatic at "high" exercise [4] would be exposed to 0.5 ppm of SO_2 for 5 minutes or more during the course of a year. The NEM accounts for population movement, activity level, and indoor vs. outdoor exposures (Biller et al., 1981).

As discussed in the reports (EPA, 1984a; EPA, 1986b,c) and supporting documents, the analyses are subject to several important limitations, and a number of major simplifying assumptions were made that may have biased the estimates. Comments received on the initial analyses (EPA, 984a) raised concerns about whether these analyses understated the extent of exposure to peak SO_2 levels (Hawkins, 1985). The major concerns were that: (1) Both limited monitoring data and theoretical calculations indicated that short-term peaks greater than 0.5 ppm could occur around numerous smaller facilities [such peaks are, however, generally of very short duration (30 seconds to 2 minutes) (EAP, 1986b, p. 9)]; and (2) because of limitations in the response of ambient monitors, the monitoring-based analysis may have underestimated the extent of hourly averages greater than 0.5 ppm and almost surely underestimated peak (less than 5 minutes) concentrations. Staff assessments of these concerns (EPA, 1986b,c) indicated that some of the factors raised may have resulted in an underestimate of exposures in the initial assessment (EPA, 1986b, pp. 18–22). However, other factors discussed in the analyses, such as the assumption that the facilities operated at full capacity for an entire year, may have resulted in an overestimate (EPA, 1986c, p. 3–32). Although the analyses are uncertain, the available results permit the following tentative conclusions:

(1) Based on current U.S. monitored air quality data and reasonable estimates of ratios of 5-minute peaks to 1-hour means, 5-minute concentrations and exposures to 0.5 ppm or more are expected primarily in the vicinity (usually less than 20 km) of major point sources such as utilities and smelters. Approximately 10 to 40 percent of the sensitive population (asthmatics) in the U.S. are estimated to live in the vicinity of utilities, with a much smaller percentage living near smelters (Thomas, 1987a).

(2) Based on modeled air quality and exposures for several large utility power plants, the current standards (24-hour and 3-hour) place substantial limits on exceedances of, and exposures to, 1-hour concentrations in excess of 0.5 ppm (Thomas, 1984).

(3) Of those asthmatics living in the vicinity (roughly 10–25 km) of the four power plants studied at their current emissions, the percentage estimated to be exposed once per year to a 5-minute SO_2 concentration of 05. ppm while at exercise varied from 1 percent to 14 percent, depending on the plant (EAP, 1986c, pp. 3–16 to 3–19). A rough extrapolation to all of the power plants in the country suggests that approximately 100,000 individual asthmatics, or about 1 percent of the national asthmatic population, will experience at least one such exposure of concern per year (Thomas, 1987a). [5] The vast majority of these 1 percent would experience only one such exposure per year.

(4) Because not all of the exposures to 0.5 ppm resulted in measurable effects in controlled studies, fewer than 25 percent of the asthmatics exposed are likely to experience even moderate pulmonary function changes and symptoms (Horstman et al., 1986). It is possible that individual asthmatics substantially more sensitive than those studied might experience larger or comparable effects at even lower levels. However, CASAC has pointed out that there is no evidence to refute or support this possibility. Moreover, severe asthmatics may be protected because they less often achieve elevated activity levels and often are already medicated to alleviate the effect of other environmental stimuli commonly encountered. The limited epidemiological data regarding peak SO_2 levels and asthma do not contradict the contention that the frequency of serious responses to SO_2 in major U.S. cities must be low. Goldstein and Weinstein (1986) found no association between emergency room visits for asthma in New York City and peak hourly SO_2 levels.

The Administrator has considered the results of these analyses together with associated uncertainties in developing this proposal. EPA has also recently received an expanded analysis of exposure prepared for the Utility Air Regulatory Group (UARG) (Teague and Minton, 1987). EPA believes that these new analyses of air quality and exposure are relevant to the final decision on the SO_2 standards and should be considered during the public comment period. Because of the preliminary nature of the UARG analysis, and because it represents an unpublished analysis that has not been considered fully by CASAC, the Administrator has not relied on the UARG exposure analysis in reaching the decision announced in today's proposal. EPA invites public comment on the UARG analysis and on the implications of the analysis for the final decision on the existing SO_2 standards as well as the alternatives. Copies of the UARG report documenting the analysis (Burton et al. 1987) have been placed in the rulemaking docket. EPA will submit the analysis to CASAC for its review.

[3] Because of the complexities involved in a full quantitative assessment of potential responses associated with alternative standards, EPA staff developed a "benchmark" for the exposure analyses termed an "Exposure of Concern" (EOC) (SPA, p. 52). Based on the assessment of effects in the criteria document addendum, the staff defined an EOC as an exposure of an asthmatic while at activities corresponding to a ventilation rate of 35 liters per minute or higher to 0.5 ppm or more of SO_2 for 5 minutes. At this level, approximately 25 percent of mild asthmatics might be anticipated to experience at least a doubling in airway resistance, which is considered to be a "moderate" response (CDA, Figure 7). A smaller percentage asthmatics could be expected to experience noticable symptoms, with some risk that the most sensitive individual asthmatics might experience a more severe response.

[4] In the NEM model, activity levels are grouped as "low," "medium," and "high". Based on the data used to generate those categories, EPA estimates that the "high" category roughly corresponds to exercise required to produce a ventilation rate of about 35 liters per minute or more (EPA 1986c, p. 2–9). This exercise rate, generally characterized by research clinicians as "moderate," is in the range where most people switch from nasal to oronasal breathing, increasing the penetration of SO_2 to sensitive receptors in the lung (SP, p. A–3). Activities producing this ventilation rate include light cycling, climbing three flights of stairs, and snow-shoveling (SP, p. A–4). Responses to 0.5 ppm of SO_2 for 5 to 60 minutes in free-breathing asthmatics have not been reported at exercise rates below this level.

[5] This rough extrapolation addressed asthmatics. If atopics or other sensitive individuals displaying hyperreactive airway response to SO_2 were included, the percent exposed would remain the same, but the absolute number exposed would increase.

(b) Determinations Concerning Protection Against 1-Hour Effects. In the Administrator's judgment, the available information on potential effects associated with short-term exposure to SO_2 and their relative frequency of occurrence given current conditions does not justify an additional level of protection beyond that already provided by the current 24-hour, 3-hour, and annual standards. As indicated by the exposure analyses described above, the current standards appear to markedly limit the frequency and extent of short-term concentrations of concern, and normal day-to-day activity patterns further reduce the chance that such concentrations will result in exposure conditions approximating those that produced effects in controlled human studies. The occurrence of SO_2-induced response is estimated to be infrequent and the direct effects observed at lower concentrations and exercise levels are transient, rapidly reversible and of uncertain health significance. A majority of the small fraction of asthmatics (~ 1 percent) exposed to 0.5 ppm SO_2 at exercise would experience no more than one such encounter per year. By comparison, a number of natural stimuli (e.g., exercise, cold air) produce comparable responses in asthmatics and many experience a number of episodes each year as a result of such stimuli. For this very reason, medication that prevents or ameliorates these effects is already routinely used by asthmatics. Finally, although there has been speculation on the point, at this time there is no convincing evidence of long-term effects associated with repeated exposures to the lower level peaks found in the ambient air (SPA, p. 32).

Given the above considerations, the Administrator is presently inclined to conclude that the current standards provide adequate protection against potential short-term effects of SO_2 and that a 1-hour primary standard is not needed. Specifically, given the protection of the current NAAQS the Administrator does not judge that the occasional remaining short-term exposures that occur constitute a significant public health problem that requires a new national ambient air quality standard. For the same reasons, the Administrator does not propose to follow the recommendation, made by some CASAC members in 1982, that in retaining the standards, the current 3-hour secondary standard be made a primary standard. Because the present standards are widely implemented, no practical environmental change would result from making the 3-hour standard a primary standard. EPA, however, does solicit public comment on the alternative of making the current 3-hour standard a primary standard.

3. 1-Hour Standard Alternative

In reaching the provisional conclusion that the current standards provide adequate protection against the potential short-term efforts of SO_2, the Administrator is mindful of the uncertainties in the scientific evidence and recent exposure analyses, and the diversity of opinion as to the possible significance of potential short-term exposures and the appropriate degree of protection. As noted above, a number of arguments have been raised in support of a 1-hour standard, and the staff paper and CASAC recommended that the Administrator consider such a standard. Given these arguments and the views of the CASAC (Lippmann, 1987); the Administrator feels it is important to air the key issues and uncertainties fully and specifically requests broad public comment and deliberation on the alternative of revising the current standards and adding a 1-hour SO_2 standard.

EPA staff and CASAC recommended a range of potential 1-hour standards for the Administrator's consideration. This range, based on the updated staff assessment (See Table 1 in Addendum I to this notice), is 0.2 to 0.5 ppm (520 to 1300 $\mu g/m^3$). Considering typical 5-minute peak to 1-hour mean ratios of 2 to 1, the lower bound (0.2 ppm) represents a 1-hour level for which the maximum 5- to 10-minute peak exposures are not likely to exceed 0.4 ppm. This is the lowest level where responses of potential clinical significance in free breathing "mild to moderate" asthamics have been reported in the literature cited in the criteria document addendum. A 1-hour standard at the upper bound of the range (0.5 ppm) would maintain maximum hourly values in the vicinity of the lowest concentrations (0.4 to 0.5 ppm) producing significant responses in the available studies summarized above. It would afford somewhat greater protection against short-term peaks than that now provided by the current standards. Based on the preliminary analysis of exposure near large point sources discussed above (SPA, Figure 4–3), it appears that under such a standard, 1 to 4 percent of the asthmatics residing in the vicinity of the point sources analyzed, or between 200 to 1400 individuals per plant, would be annually exposed while at exercise to 5-minute peaks at or above 0.5 ppm. On a national level, fewer than 1 percent of all asthmatics would experience such exposures. Nevertheless, a 0.5 ppm level would not completely preclude 5- to 10-minute exposures on the order of 1 ppm.

Considering typical 5-minute peak to 1-hour mean ratios of 2 to 1 or lower, 1-hour standard alternatives of 0.3 to 0.4 ppm could result in 5-minute peaks on the order of 0.6 to 0.8 ppm. Several CASAC members supported a 1-hour standard in this portions of the overall range (Lippmann, 1987). If a 1-hour ambient standard of 0.4 ppm were implemented at the four power plants studied in the exposure analysis discussed above, the percentage of the asthmatics living in the vicinity of those plants who would be exposed once per year to a 5-minute SO_2 concentration of 0.5 ppm while at exercise would be less than 1 to 2 percent (EPA, 1986c, p. 3–22).

After considering the views of CASAC, the Administrator is inclined to conclude that a 1-hour primary ambient standard to protect exercising asthmatics and atopics from short-term exposures to SO_2 is not warranted. As explained above, this inclination is based, on among other things, the uncertain significance of the health effects involved and on the infrequence of inducement of such effects by SO_2. However, the Administrator solicits comment on the alternative of a 1-hour standard at the level of 0.4 ppm.

The promulgation of a 1-hour standard would also prompt consideration of additional revisions that would affect the remaining standards. Following recommendations of staff (SP, p. 112) and CASAC, if EPA promulgated a 1-hour standard, it would consider replacing the current secondary 3-hour standard (0.5 ppm) with a 1-hour secondary standard set equal to the primary standard. This standard would provide welfare protection at least as stringent as the current standard. A second revision that would be considered if a 1-hour standard were promulgated is the adoption of an expected exceedance form for all of the standards. This potential revision is discussed in a subsequent section.

C. Averaging Convention for the Standards

The averaging convention specifies the interpretation of standards for a particular averaging time (in this case, 3-hour, 24-hour, annual) with respect to when (time and day) the averaging period(s) begins and ends. The two major alternative averaging conventions are known as "block" and "running". Under the block convention, periods such as 24-hours and 3-hours are measured sequentially and do not overlap; when one averaging period ends, the next begins. For example, one

24-hour measurement would be taken from midnight on day one to midnight on day two; the next would begin at midnight on day two. Under the running convention, measurements are allowed to overlap. Thus, if one 24-hour period were measured from midnight to midnight, the next might be measured from 1 a.m. to 1 a.m. or from 12:01 a.m. to 12:01 a.m. Given a fixed standard level, running averages would produce a somewhat more restrictive standard (Faoro, 1983; Possiel, 1985).

Although the wording of the original 24-hour, 3-hour, and annual SO_2 standards was ambiguous on the matter, the earliest actions of EPA signify that the block averaging convention was intended for these standards (OAQPS, 1986), and block averages have generally been used in implementing the standards.[6] The use of running averages would therefore represent a tightening of the standards. Because the Administrator has determined, for the reasons explained above, that protection of the public health does not require tightening the standards, the Administrator proposes to retain the block averaging convention for the 24-hour, 3-hour, and annual standards. To eliminate any future questions on this aspect of the standards, clarifying language is being proposed in the regulation (40 CFR 50.4 and 50.5). Nevertheless, the Administrator solicits comment on the alternative running-average convention for the 24-hour and 3-hour standards.

D. Form of the Standards

In revising the standards for ozone and particulate matter, EPA concluded that it would be appropriate to make technical improvements to the form in which the standards were expressed (44 FR 8202 and 52 FR 24653). These improvements were embodied in a revised statistical form for the standards, which was intended to maintain desired health protection while improving ease of implementation. The decisions on the statistical form were made in conjunction with decisions on the level of the standard. EPA has also considered the alternative of expressing the SO_2 standards in a similar statistical form, with one expected exceedance per year for the 24-hour and 3-hour standards and expressing the annual standard as an expected annual mean. EPA examined the relative protection afforded by the current standards if they were expressed in statistical form (EPA, 1984a; Frank, 1987). These analyses found that the standards expressed in a statistical form would afford reduced protection against the 24-hour, annual, and 3-hour health and welfare effects identified above and, in addition, would permit an order of magnitude increase in the number of asthmatics exposed to 0.5 ppm SO_2 for 5-minutes at exercise. As noted above, the Administrator has concluded that the level of protection provided by the current standards against the health and welfare effects of SO_2 is necessary and should be retained. Thus, adopting a statistical form would necessitate revisions to the levels of the standards to maintain that level of protection. In the judgment of the Administrator, the limited technical advantages of the statistical form are not sufficient to warrant the administrative burden associated with such a change. Therefore, EPA proposes to maintain the current form of the SO_2 standards.

If EPA promulgated a 1-hour standard, however, it would consider changing the form of the 24-hour and annual standards. As discussed above, EPA does not feel these changes would be appropriate if the current standards are retained at the present levels with no 1-hour standard.

A detailed description of the possible alternative forms for the 1-hour, 24-hour, and annual standards has been developed (Frank, 1987) and placed in the rulemaking docket. As presented there, the standards would be attained when the expected number of exceedances of the 24-hour and 1-hour standards level is no more than one per year. Generally, the determination would be based on three consecutive years of data. Although expressing the 24-hour standard in statistical form results in less protection than provided by the present deterministic form, the protection against the effects associated with 24-hour exposures would remain adequate because of the additional stringency afforded by the 1-hour standard alternative.

The annual SO_2 standard would be expressed as an expected annual arithmetic average determined by averaging the annual arithmetic averages, generally from three successive years of data. Expressing the annual standard in this form would result in a somewhat less restrictive standard than provided by the current form. Any decrease in protection would, in the majority of cases, however, be more than compensated by the general increase in protection provided by the 1-hour standard alternative.

The interpretation of the alternative forms developed for 1-hour, 24-hour, and annual standards (Frank, 1987) is conceptually similar to that promulgated in Appendix K of the Particulate Matter Standard (52 FR 24634). Some differences exist, however, with respect to treatment of incomplete data.

III. Proposed Action on Standards

As stated above, based on the data presented in the criteria document, assessments and analyses in the staff paper, and CASAC recommendations, the Administrator proposes not to revise the current 24-hour, annual, and 3-hour SO_2 standards.

EPA is proposing to make some minor technical changes in the Part 50 regulations concerning the SO_2 standards (Frank, 1988). First, the levels for the primary and secondary NAAQS would be restated in ppm rather than $\mu g/m^3$ (40 CFR 50.4 and 50.5). This would be done to make the SO_2 NAAQS consistent with other pollutants and to improve understanding by the public. Secondly, explicit rounding conventions would be added (40 CFR 50.4 and 50.5). This would aid State and local air pollution control agencies in interpreting the standard. Finally, data completeness and handling conventions would be specified (40 CFR 50.4 and 50.5). These conventions would be consistent with the definitions used with ozone and would ensure that omission or deletion of some hourly data will not negate obvious exceedances of the short-term standards (see 40 CFR Part 50, Appendix H for the equivalent ozone language).

IV. Acid Deposition

Among the major welfare effects associated with sulfur oxides emissions are those related to the acidic deposition phenomenon. The issue of acidic deposition was not, however, assessed directly in the OAQPS staff paper because EPA has followed the guidance given by CASAC on this subject at its August 20–22, 1980 public meeting on the draft document, "Air Quality Criteria for Particulate Matter and Sulfur Oxides." The CASAC concluded that acidic deposition is a topic of extreme scientific complexity because of the difficulty in establishing firm quantitative relationships between emissions of relevant pollutants, formation of acidic wet and dry deposition products, and effects on terrestrial and aquatic ecosystems.

[6] Although EPA generally does not specify use of a running average in evaluating SO_2 SIPs for attainment and maintenance of the NAAQS, running averages have been used in a limited number of instances. In the enforcement context, in cases where supplementary control systems (SCS) were used as an interim measure to protect the NAAQS at primary copper smelters, consent decrees for such facilities specified running average requirements. *See, e.g., U.S.* v. *Phelps Dodge Corp.*, Civil No. 81-088-TUC-MAR (D. Ariz. filed October 20, 1988).

CASAC also noted that acidic deposition involves, at a minimum, several different criteria pollutants—oxides of sulfur, oxides of nitrogen, and the fine particulate fraction of suspended particles. Finally, the Committee felt that any document on this subject should address both wet and dry deposition, since dry deposition is believed to account for at least one-half of the total acid deposition problem. For these reasons, the Committee felt that a separate comprehensive document on acidic deposition should be prepared prior to any consideration of using NAAQS as a regulatory mechanism for control of acidic deposition. CASAC also suggested that a discussion of acidic deposition be included in the criteria documents for both nitrogen oxides (NO_x) and particulate matter/sulfur oxides. In response to these recommendations, EPA subsequently prepared the following documents: The Acidic Deposition Phenomenon and Its Effects: Critical Assessment Review Papers, Volume I and II (EPA, 1984b), and The Acidic Deposition Phenomenon and Its Effects: Critical Assessment Document (EPA, 1985). Although these documents are not criteria documents and have not undergone CASAC review, they are the most recent comprehensive summary of relevant scientific information on acidic deposition completed by EPA.

The review of the implications of scientific information on acidic deposition for current and alternative sulfur oxides standards has taken place in the larger context of the examination of the acid deposition issue as a whole. The administrator has thoroughly reviewed this issue and has been kept apprised of the most recent scientific information on a continuing basis. This examination has included a review of options for addressing the issue through mechanisms available under current Act authority including secondary air quality standards as well as alternative emissions reductions mechanisms. Based on this review, the Administrator has reached the following conclusions of relevance for sulfur oxides standards:

1. Based upon the current scientific understanding of the acid deposition problem, it would be premature and unwise to prescribe any regulatory control program at this time.

2. When the fundamental scientific uncertainties have been reduced through ongoing research efforts, EPA will craft and support an appropriate set of control measures.

Based on these conclusions, the Administrator does not, at this time, believe it is appropriate to propose a separate secondary sulfur oxides standard to provide increased protection against the acid deposition-related effects of sulfur oxides.

V. Significant Harm Levels and Episode Criteria

Section 303 of the Act authorizes the Administrator to take certain emergency actions if pollution levels in an area constitute "an imminent and substantial endangerment to the health of persons." The Act and EPA's regulations governing adoption and submittal of SIP's (section 110(a)(2)(F)(v) and 40 CFR 51.16 and subpart H of Part 51) require States to adopt contingency plans to prevent ambient pollutant concentrations from reaching specified Significant Harm Levels and to take additional abatement actions if such levels are reached. The existing Significant Harm Levels (40 CFR 51.16a) for SO_2 were established in 1971 (36 FR 24002, November 21, 1971) at the following levels:

SO_2 Alone—1.00 ppm (2620 $\mu g/m^3$) 24-hour average of SO_2

SO_2 x TSP—490x103 ($\mu g/m^3$)2—24-hour average product of SO_2 and TSP concentrations

On the basis of EPA's reassessment of the data upon which these levels were based and its assessment of more recent scientific evidence on sulfur oxides and particulate matter, EPA proposes to revise the Significant Harm Levels for SO_2.

A. 24-Hour Levels

In actions related to the recent revisions of the particulate matter standards, EPA has already eliminated the combined TSP-SO_2 Significant Harm Level (52 FR 24672, July 1, 1987). In doing so, EPA left open the possibility of reinstating a PM_{10}-SO_2 Significant Harm Level, if necessary for additional protection against SO_2 effects, at the conclusion of the SO_2 review. The scientific data suggest that SO_2 in combination with high levels of particulate matter has been associated with increases in daily mortality. The final 24-hour PM_{10} Significant Harm Level of 600 $\mu g/m^3$ takes this potential interaction into account. Addition of a combined SO_2-PM_{10} Significant Harm Level therefore appears unnecessary.

Removal of the combined Significant Harm Level raises the question as to whether the remaining SO_2 Significant Harm Level is sufficient. The possibility that SO_2 alone or in combination with other pollutant or fog droplets may be in part responsible for the effects associated with 24-hour exposures suggests the need to continue a 24-hour Significant Harm Level for SO_2 along at a substantially lower concentration. EPA's assessment of studies of daily mortality (CDA, Table 1; SPA, Table 4–2) indicates greatest certainty of some increased daily mortality associated with high particle concentrations in combination with SO_2 levels at or above 750 $\mu g/m^3$ (0.29 ppm) for 24-hours. Accordingly, EPA proposes to revise the 24-hour SO_2 Significant Harm Level to 0.29 ppm (750 $\mu g/m^3$).

Appendix L to Part 51 contains example air pollution episode levels and example contingency plans for the purpose of preventing air pollution from reaching the Significant Harm Levels prescribed in Section 51.151. The examples in Appendix L serve as guides to States for the development of their own contingency plans. To conform with the proposed revisions to the Significant Harm Level for SO_2, certain changes to Appendix L are required. EPA proposes the following revisions to the example 24-hour episode levels for SO_2:

(1) That the example Alert Level for SO_2 be changed from 800$\mu g/m^3$ to 0.19 ppm (500 $\mu g/m^3$), 24-hour average;

(2) That the example Warning Level for SO_2 be changed from 1600 $\mu g/m^3$ to 0.23 ppm (600 $\mu g/m^3$), 24-hour average; and

(3) That the example Emergency Level for SO_2 be changed from 2100 $\mu g/m^3$ to 0.26 ppm (675 $\mu g/m^3$), 24-hour average.

The basis for changing the episode levels for SO_2 is the same as discussed above for the revisions to the Significant Harm Level. With respect to example episode levels, the proposed Alert Level reflects the upper bound of the 24-hour range of interest for the NAAQS presented in the staff paper addendum (Table 2). The staff paper concludes that at or above 0.19 ppm (500 $\mu g/m^3$) for 24 hours, health effects are likely to occur in certain sensitive population groups (SP, p. 72). Therefore, it would be appropriate under the episode criteria to initiate first stage control action when this ambient level of SO_2 occurs. The proposed 24-hour Warning and Emergency Levels are set at increments between the proposed Alert Level and the proposed Significant Harm Level. This approach would provide opportunity for the control actions associated with each episode level to take effect before the next stage is triggered and additional control actions become necessary. This proposal, if adopted, would change the 24-hour Significant Harm Level. Therefore, States would be required to adopt the new numerical level; to evaluate the emergency episode provisions in their current SIP's and any permits containing such provisions; and to make any

revisions necessary to assure their adequacy.

B. 1-Hour Levels

As discussed in section II. of this notice, EPA has evaluated substantial new information concerning the effects of short-term (5 to 10 minute) exposures to peak concentrations of sulfur dioxide. In that section, EPA tentatively concluded that the existing ambient standards provide adequate protection against the effects that might be experienced by asthmatics exercising in the vicinity of major point sources, but solicited public comment on the alternative of adding a 1-hour primary ambient standard to provide additional protection against such effects. EPA believes, however, that for reasons discussed below it would be appropriate to set a short-term (one-hour or less) Significant Harm Level.

Although controlled human exposure data at very high SO_2 concentrations are limited by study design, the available data suggest that 5-minute levels on the order of 2 to 5 ppm can cause effects that are intolerable to some exercising asthamatics (SP, Table 5–3 p. 32; CD, Table 13–2 pp. 13–7 to 13–10; SPA, Table 4–1 p. 38), and that exposures at the upper end of this range can cause severe effects in resting asthamatics and atopics as well as pulmonary changes and symptoms in nonasthmatic, nonatopic adults (SP, p. 36).

In most instances, such high peak concentrations would be associated with exceedances of the existing 3-hour (0.5 ppm) and 24-hour (0.14 ppm) ambient standards. Nevertheless, a Significant Harm Level in addition to the existing standards would provide: (1) Protection against very high peak concentrations, (2) emergency responses to transient events that have not been anticipated and prevented by the normal implementation process associated with the ambient standards, (3) action to address the very highest concentrations pending attainment of the standards in areas not currently in attainment of the ambient standards, and (4) remedial action with respect to those very few sources with such highly variable emissions that exceedances of the Significant Harm Level might occur without corresponding exceedances of the 3-hour or 24-hour ambient standards.

On the basis of the data discussed above, EPA proposes to set a Significant Harm Level for SO_2 at a 5-minute average concentration of 5 ppm. Because of the difficulties in modeling and monitoring such short-term concentrations, EPA also proposes to implement the Significant Harm Level through a 1-hour Guide. Given the typical two-to-one ratio between 5-minute and 1-hour average concentrations (SPA, p. 5–6), EPA proposes to use a 1-hour Guide of 2.5 ppm.

EPA's preliminary review of both monitored and modeled air quality data indicates that only a limited number of sources in a few areas have the potential to exceed the proposed 1-hour Significant Harm Guide (Thomas, 1987b). The review found the 1-hour Significant Harm Guide was exceeded around a few large point sources and in particular around primary copper smelters. In addition, modeled air quality data suggest that a small number of power plants may, under some circumstances, exceed the 1-hour Significant Harm Guide.

EPA has traditionally relied upon episode criteria as a way of triggering abatement actions necessary to avoid an exceedance of the Significant Harm Level. As a result, EPA also proposes for public comment the following example episode criteria which, if adopted, would be added to Appendix L of Part 51:

(1) An example Alert Level of 0.75 ppm (1960 $\mu g/m^3$) SO_2, 1-hour average;

(2) An example Warning Level of 1.0 ppm (2620 $\mu g/m^3$) SO_2, 1-hour average; and

(3) An example Emergency Level of 1.5 ppm (3930 $\mu g/m^3$) SO_2, 1-hour average.

One hour, rather than 5 minute, episode criteria are specified because of the aforementioned practical constraints associated with implementing shorter duration criteria. Since this proposal, if adopted, would add a new Significant Harm Level and Guide, States would need to evaluate the emergency episode provisions in their current SIP's, and any permits containing such provisions, making any revisions that may be necessary to assure the adequacy of the contingency plans required by Clean Air Act section 110(a)(2)(F)(v) and by 40 CFR 51.16 and Subpart H of Part 51.

Short-term peaks (5-minute to 1-hour) of SO_2 occur sporadically, on a very localized scale, and usually with little or no build-up of SO_2 levels before the occurrence of the peak. The rapid onset and quick dispersal of SO_2 peaks raise several issues regarding the appropriateness of the proposed example episode criteria and how States should develop and implement contingency plans to assure that the proposed Significant Harm Level and Guide are not exceeded. EPA specifically requests public comments on the following issues:

(1) Traditional Approach

Protection of the Significant Harm Level has traditionally relied upon sources taking abatement measures as pollution levels build. The nature of the SO_2 peaks raises questions as to whether or not monitoring data coupled with the short-term episode criteria and abatement techniques can be relied on to prevent the Significant Harm Level from being exceeded. EPA specifically solicits comment on how the traditional approach might be modified or revised to overcome these concerns. (For example, to reduce the number of monitors required, air quality models could be used to screen for the locations expected to experience the highest short-term SO_2 concentrations.)

(2) Alternative Approaches

Given the potential limitations and costs of the traditional approach, EPA also solicits comment on alternative approaches. One such approach might rely on modeling to predict peak SO_2 concentrations. However, since models cannot determine the occurrence of an actual peak, such an approach may require continuous or seasonal emissions controls. Any alternative to the traditional approach could be federally imposed only to the extent that it is consistent with the requirements and limitations of the Act; specifically sections 303(a), 301(a) and 110(a)(2)(F)(v). There is also a question as to the role of episode criteria under such alternative approaches.

All public comments on the proposed Significant Harm Level and episode criteria, the approaches that EPA is considering in implementing the proposed Significant Harm Level, and any other issues relative to the implementation of the Significant Harm Level and Guide will be considered by the Agency as it makes a decision on the final Significant Harm Level and develops subsequent rulemaking on the Agency's guidance for implementing the final Significant Harm Level. Prior to any final action on the implementation guidance, EPA will propose such guidance in the **Federal Register** for public comment.

VI. Federal Reference Method and Monitoring Requirements

Concerning the measurement method for sulfur dioxide, no revisions are being proposed to the reference method described in Appendix A to Part 50. No changes have been suggested since EPA recently (December 6, 1982) promulgated modifications to Appendix A (47 FR 54899). The 1982 changes incorporated technical improvements developed

subsequent to the 1971 reference method promulgation.

EPA has also reviewed the current ambient air quality monitoring programs conducted in accordance with the existing regulations (40 CFR Part 58) and has concluded that only minor modifications of the regulation are necessary in conjunction with the proposed decision not to revise the NAAQS and to revise the Significant Harm Level and episode criteria. These modifications are summarized below.

(1) Monitoring Method (Appendix C)

Revisions are proposed to Appendix C that would add a new section 2.4 that would require SO_2 analyzers to be operated on the lowest (narrowest) approved range that will measure expected peak concentrations without exceeding maximum values for the range selected. Previously, some monitors were operated on ranges that occasionally were too low to measure peak concentrations.

(2) Annual SLAMS Report (Appendix F)

A proposed revision to Section 2.1.1 of Appendix F would reword this section to provide greater clarity. Section 2.1.2 would similarly be reworded for clarity and to require that the 24-hour averages reported in the annual report for SO_2 be based on block (midnight to midnight) averaging periods and the 3-hour averages also to be based on block averaging periods.

(3) Air Quality Index Reporting and Daily Reporting (Appendix G)

EPA proposes to revise the SO_2 ambient concentrations contained in Tables 1 and 2 and in Figure 3, to correspond to the proposed new episode criteria and Significant Harm Levels.

VII. Regulatory and Environmental Impacts

A. Regulatory Impact Analysis

Under Executive Order 12291, EPA must judge whether a regulation is a "major" regulation for which a Regulatory Impact Analysis (RIA) is required. EPA has judged the sulfur oxides NAAQS proposal to be a major action, and has prepared a draft RIA based on information developed by several EPA contractors (inter alia, ICF, 1984; Anderson et al., 1984). The RIA includes estimates of costs, benefits, and net benefits associated with alternative SO_2 standards. The draft analysis, entitled Regulatory Impact Analysis of the National Ambient Air Quality Standards for Sulfur Oxides-Draft (EPA, 1988), is available from the address given above (see Availability of Related Information section). A final RIA will be issued at the time of promulgation of final standards. Neither the draft RIA nor the contractor reports have been considered in issuing this proposal.

The draft RIA has been submitted to the Office of Management and Budget (OMB) for review under Executive Order 12291. Written comments from OMB and any EPA written responses to those comments are available for public inspection EPA's Central Docket Section (Docket No. A-84-25), South Conference Center, Room 4, Waterside Mall, 401 M Street, SW., Washington, DC 20460.

B. Impact on Reporting Requirements

The proposed rule does not impact any information collection requirements currently cleared under OMB Control Number 2060-0084.

C. Impact on Small Entities

Under the Regulatory Flexibility Act, 5 U.S.C. 600 et seq., EPA must prepare a regulatory flexibility analysis assessing the impact of any proposed or final rule on small entities. Under 5 U.S.C. 605(b) this requirement may be waived if EPA certifies that the rule will not have a significant economic affect on a substantial number of small entities. Small entities include small businesses, small not-for-profit enterprises, and governmental entities with jurisdiction over populations of less than 50,000.

A decision not to revise the current NAAQS for SO_2 would, of course, impose no new requirements. In addition, the SIP's necessary to implement these NAAQS have been substantially adopted. Additional SIP requirements will be needed only for those areas and sources which are currently designated as nonattainment for SO_2. A preliminary assessment of remaining nonattainment areas indicates that, in general, only major sources such as utilities, primary smelters, and refineries owned by large businesses would be affected by any additional SIP requirements. In addition, the total number of sources is very small. These assessments suggest that any additional SIP requirements will not significantly affect a substantial number of small entities.

Furthermore, the control measures necessary to attain and maintain the NAAQS are developed by the respective States as part of their SIP's. In selecting such measures, the States have considerable discretion so long as the mix of controls selected is adequate to attain and maintain the ambient standards. Whether a particular standard would have a significant effect on a substantial number of small entities therefore depends on how the States would choose to implement it. For these reasons, any assessment performed by EPA on the impacts of additional SIP requirements at this time would necessarily be speculative. On the basis of the above considerations and findings, the administrator certifies that a decision not to revise the sulfur oxides standards will not have a significant impact on a substantial number of small entities.

VIII. Other Reviews

This proposed rule was submitted to the OMB for review. Written comments from OMB and EPA written responses to these comments are available for public inspection at EPA's Central Docket Section (Docket No. A-84-25), South Conference Center, Room 4, Waterside Mall, 401 M Street, SW., Washington, DC.

List of Subjects in 40 CFR Parts 50, 51 and 58

Intergovernmental relations, Air pollution control, Carbon Monoxide, Ozone, Sulfur oxides, Particulate matter, Nitrogen dioxide, Lead.

Dated: April 13, 1988.

Lee M. Thomas,

Administrator.

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Addendum I—CASAC Review and Closure of the 1982 Criteria Document for Particulate Matter/Surfur Oxides and the 1986 Second Addendum to the Criteria Document

January 29, 1982.

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

From: Sheldon K. Friedlander, Chairman, 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 fulfulls 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 of 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 Surlfur Oxides once that document becomes available and its review is completed.

Major Scientific Issues and CASAC Conclusions in the SOx/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 equivalency 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 SOx/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 SOx/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 effect 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.

October 6, 1983.

Terry F. Yosie, Science Advisory Board, U.S. Environmental Protection Agency, Washington, D.C. 20460.

Dear Terry: Here is my amended statement on the SO_x closure letter, etc. to the Administrator. I apologize for the delay in getting it to you, due to my having been out of town.

I am uncertain of the correct procedure. Should I send the statement to the Administrator or should you or Mort Lippmann or Bernie Goldstein?

Yours sincerely,

Ian T. T. Higgins, M.D.,

Professor of Epidemiology.

cc: Dr. Morton Lippmann, Dr. Bernard Goldstein.

Minority Statement

By Ian Higgins

I do not believe that the letter to the Administrator and the Findings, Recommendation and Comments of the Clean Air Scientific Advisory Committee on the OAQPS Staff Paper for Sulfur Oxides reflect the widely divergent views of committee members adequately. Certainly my own views on the key issues are sufficiently different that I feel I have no alternative but to state them.

I do not think that the third paragraph of the letter states the options correctly. There are, in fact, not two, but four choices. In addition to the two mentioned, the standards could be left unchanged or they could be relaxed. Both of these options were mentioned in the meeting. My own view is that from a health standpoint, they could be relaxed slightly without anyone being one whit the worse. But I am not in favor of pollution and I would settle for maintaining them unchanged, which was, I thought, the majority view of the committee. I do not believe there is sound evidence to support the adoption of a 0.5 ppm three-hour standard. I think there is even less justification at this time for a one hour standard. The suggestion for a one-hour standard comes from studies in which asthmatic subjects have been exposed in the laboratory to different concentrations of sulfur dioxide while exercising. In the course of its deliberations, the Committee heard evidence from some of the leading world experts on air pollution and asthma. The President-Elect of the American Thoracic Society for example, in his statement on these exposure studies, expressed "deep concern, if not dismay, that environmental standards entailing great costs could possibly be based on these data." This reflects my own views admirably. Asthmatic subjects are well known to have bronchial hyper-reactivity. Increases in airways resistance, similar to those produced by sulfur dioxide occur in response to deep breathing, coughing, exposure to cold air and naturally occurring pollens. These increases are transient and pass off rapidly when exposure ceases. Moreover, some studies have shown that they also pass off when exposure is continued. This seems to indicate clearly that they should be regarded as an adaptive response. In any case, they are seldom accompanied by symptoms, do not lead to any short or long-term consequences and therefore should not be considered to be adverse health effects. There is no sound evidence that current levels of sulfur dioxide are responsible for excess asthmatic attacks in the community. Finally, the likelihood of an exercising asthmatic ever encountering a one-hour concentration of 0.5 ppm sulfur dioxide is very small. All in all, the institution of a one-hour standard for sulfur dioxide would be a good example of the proverbial sledgehammer to crack a nut.

Turning to the Findings, Recommendations and Comments, I do not believe that sulfur dioxide continues "to pose a serious health problem to important subgroups of the population." In my view, it is a trivial problem if it exists at all.

The first sentence on page 2, "CASAC concludes that separate SO_2 and particles standards each set with appropriate consideration for potential interactions, does appear to protect public health," is difficult to understand. If it means that the standards do protect public health, I agree. However, the rest of the comments and recommendations seem to imply that they do not. This must be confusing the Administrator.

I do not believe that the epidemiological evidence suggests that there is no threshold and that "risk increases as concentration levels increase." Lawther's studies showed increases in respiratory illness in bronchitic subjects at concentrations of SO_2 of 500–600 ug/m^3 and over when these occurred with concentration of particles (British smoke) of 250–300 ug/m^3 and over, but not at levels below this concentration. This suggests a practical threshold for the most sensitive subjects that have been studied epidemiologically.

The work of Maxumdar et al. showed little evidence of any role of SO_2 once particulates were adequately allowed for. Any possible effect appeared to occur only at concentrations in excess of 750 ug/m^3 with particulates.

The reference to animal toxicology implies that such studies have shown serious effects. In fact, the remarkable findings of the experiments on animals (including primates) has been the lack of serious short or long term consequences of exposures to SO_2 far in excess of any ever encountered by man.

The CASAC spent some time deliberating on the logistical problems of one-hour standard. I do not, however, believe that we reached a clear idea of the problems, difficulty and costs of introduction of such a standard. In summary, I believe the current standards for SO_2 are adequate to protect the public health with a margin of safety. I do not believe the evidence indicates that any additional standards are needed.

December 15, 1986.

The Honorable Lee M. Thomas, Administrator, U.S. Environmental Protection Agency, Washington, DC 20460.

Dear Mr. Thomas: The Clean Air Scientific Advisory Committee (CASAC) has completed its review of two documents related to the development of National Ambient Air Quality Standards (NAAQS) for Particulate Matter and Sulfur Oxides. These two documents are the 1982 *Air Quality Criteria for Particulate Matter and Sulfur Oxides,* and the 1986 *Second Addendum to Air Quality Criteria for Particulate Matter and Sulfur Oxides (1982),* both prepared by the Agency's Environmental Criteria and Assessment Office (ECAO).

The Committee was impressed with the efforts of the staff of ECAO in preparing a well written, integrated and thorough review of recent relevant scientific studies. The Committee unanimously concluded that this 1986 Addendum, along with the 1982 Criteria Document previously reviewed by CASAC, represent a scientifically balanced and defensible summary of the extensive scientific literature on these pollutants.

Several important issues are discussed in the 1986 Addendum which the Committee believes should be emphasized. These issues were raised during our review of recent studies which relate primarily to guidance at the lower bounds of the ranges for the standards. These studies include the recent reanalyses of the London mortality data, two episodic lung function studies in the United States and the Netherlands, and the comparison of respiratory symptoms and

pulmonary function levels of children living in six U.S. cities. Further discussion of these studies and reanalyses, as well as a more detailed discussion of the basis for the Committee's conclusion, are contained in the attached report.

The Committee also reviewed the Staff Papers for particulate matter and for sulfur oxides at the October 15–16, 1986 meeting, and is preparing separate reports reflecting its conclusions and recommendations on each of these two documents.

Thank you for the opportunity to present the Committee's views on these important public health issues.

Sincerely,

Morton Lippmann, Ph.D.,

Chairman, Clean Air Scientific Advisory Committee.

cc: A. James Barnes, Lester Grant, Vaun Newill, Craig Potter, Terry Yosie.

Summary of Major Scientific Issues and CASAC Conclusions on the 1986 Addendum to the 1982 Particulate Matter/Sulfur Oxides (PM/SO_x) Criteria Document

The Committee concentrated its review on newer studies and analyses which relate primarily to guidance on the lower limit of the proposed ranges for the standards. In general, the Committee believes the Criteria Document Addendum has appropriately summarized and interpreted the designs, analyses and conclusions of studies that should be considered in the standard setting process. The following is a brief chapter by chapter summary of issues that the Committee wishes to emphasize, or which require further clarification.

Chapter 1: Introduction

In general, this chapter provides an excellent summary of the physical and chemical properties and ambient measurement methods for PM and SO_x. However, the chapter could be strengthened by inclusion of a discussion of direct reading monitors for particulate mass concentrations including beta attenuation, light scattering, or other techniques which may be the dominant measurement techniques in the States in the future. This was discussed at the December 1985 CASAC meeting, with emphasis on the need to move to automated and continuous monitoring for particles.

Chapter 2: Respiratory Tract Deposition and Fate

The presentation in this chapter could be expanded by clarifying the discussion concerning the concept of impaired lungs and the deposition that would occur there as opposed to that in normal subjects. Further, the discussion of broncho-constriction being protective (Svartengren et al., 1984) and the discussion of other types of altered breathing patterns could be made clearer, perhaps by reorganizing this information by specific points.

Chapter 3: Epidemiology Studies

We wish to emphasize several studies and analyses discussed at the October 1986 CASAC meeting. One of these studies (Dassen et al.) should be integrated into this chapter, as was recognized by Agency staff in their remarks at the October 1986 meeting.

(1) The two episodic lung function studies show a consistency of results in Steubenville, Ohio (Dockery et al.) and Ijmond, Netherlands (Dassen et al.), lending credence to reported effects of a mixture of PM and sulfur oxides (SO_x) on respiratory function in children. This is consistent with the earlier work of Stebbings. These studies provide a relatively sensitive indication of possible short term physiological responses of uncertain health significance to PM. The roles of exposure times and duration of functional decrement need better definition.

(2) The London mortality studies, including recent analysis by Agency staff, provide strong evidence that particulate matter is more closely associated with daily mortality than sulfur dioxide concentrations. The criteria document should recharacterize distinctions made between "likely" and "possible" effects levels for establishing upper bounds.

(3) The Six-Cities study has reported that cough and bronchitis are twice as prevalent in children living in cities with PM_{10} in the range of 40–60 ug/m^3, in comparison to cities with a range of 20–30 ug/m^3.

Chapter 4: Controlled Human Exposure Studies of SO_2 Health Effects

Although this chapter was well done, the Committee suggests that it be strengthened by modifying its existing discussions and by addition of further discussion and tabular material concerning short term exposure effects presented by Drs. Horstman and Folinsbee at the October 1986 CASAC meeting.

Conclusion

The 1986 Addendum to the 1982 Air Quality Criteria Document on PM/SO_x was prepared by EPA at the request of CASAC for the purpose of updating the knowledge of recent scientific studies and analyses. The Committee commends the agency staff for its efforts in preparing a concise and well written document. The Addendum summarizes key findings from the earlier documents and provides a reasonably complete summary of newly available information concerning particulate matter and sulfur oxides, with major emphasis on evaluation of human health studies published since 1981. The Committee unanimously concludes that this 1986 Addendum, with the incorporation of the changes noted above, represents a scientifically balanced and defensible summary of the extensive scientific literature on these pollutants. These documents fulfill the requirements under section 108 of the Clean Air Act as amended, which requires that the document(s) "* * * shall accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare * * *" from particulate matter and sulfur oxides in the ambient air.

Addendum II—CASAC Review and Closure of the 1982 OAQPS Staff Paper on Sulfur Oxides and the 1986 Addendum to the Staff Paper

August 26, 1983.

Honorable William D. Ruckelshaus,
Administrator, Environmental Protection Agency, Washington, DC. 20460.

Dear Mr. Ruckelshaus: The Clean Air Scientific Advisory Committee (CASAC) has completed its second and final review of the revised draft Office of Air Quality Planning and Standards (OAQPS) Staff Paper entitled *Review of the National Ambient Air Quality Standards for Sulfur Oxides: Assessment of Scientific and Technical Information.*

The document is consistent in all important aspects with the scientific evidence presented and interpreted in the combined criteria document for sulfur oxides and particulate matter. It has organized the data relevant to the establishment of sulfur dioxide primary and secondary ambient air quality standards in a logical and compelling way, and the Committee believes that it provides you with the kind and amount of technical guidance that will be needed to make appropriate decisions about revisions to the standards.

During the course of the Committee's review of the Staff Paper for Sulfur Oxides a number of significant scientific issues related to the establishment of primary and secondary standards were addressed. A review of the existing data base for this pollutant led the Committee to conclude that there are two scientifically supportable options for revising the existing standards. One option for which there is strong but not unanimous support on CASAC includes the following: establishment of a new 1-hour primary standard in the range between .25–.75 parts per million, retention of a 24-hour primary standard, conversion of the current .03 ppm annual primary standard to an annual secondary standard at or below that level, and selection of a revised 3-hour secondary standard between a range of .40–

.50 ppm. The other option for which there is some support on the Committee is to retain the existing primary and secondary standards, while providing some additional public health protection by converting the existing 3-hour secondary standard into a primary standard. The choice between these options is a policy decision which is not within the scope of the Committee's mission. CASAC's wishes to inform you that either of these options would be supported by the available scientific evidence.

Other scientific issues and studies of interest to the review and possible revision of the primary and secondary standards are reviewed in the attached report. In addition, I have attached a recent CASAC report on research needs for the gases and particles program within the Agency. It is clear that there are major gaps in our understanding of these pollutants and that the Agency should develop a more balanced and more adequately funded research program.

I hope the CASAC's findings and recommendations prove useful to you as you review and consider revisions to the sulfur dioxide standard. The Committee appreciates the opportunity to advise you on this important issue, and it will provide further review and comment to you during the public comment period that follows the proposal of revised standards in the **Federal Register**.

Sincerely,

Bernard D. Goldstein,

Chairman, Clean Air Scientific Advisory Committee.

Attachment.

cc: Alvin Alm, Charles Elkins, Terry F. Yosie.

Findings, Recommendations and Comments of the Clean Air Scientific Advisory Committee on the OAQPS Revised Draft Staff Paper for Sulfur Oxides

CASAC's evaluation of the scientific basis for a review and possible revision of the ambient air quality standards for sulfur dioxide began with its recommendation in November 1978 that the Agency evaluate the joint interaction of sulfur oxides and particulate matter on human health and the environment by the development of a joint criteria document for these pollutants. Following three public reviews of the criteria document and its subsequent revision by Agency staff, the Committee concluded in a letter to the Administrator dated January 29, 1982 that the Agency's assessment of the existing literature for these pollutants was scientifically adequate. This report addresses the OAQPS staff's interpretation of the criteria document and the scientific rationale that is developed to support their proposals for reviewing and revising the SO_2 standards.

The Scientific Basis for Primary SO_2 Standards

1. A major OAQPS conclusion of the criteria document review process was that sulfur dioxide continued to pose a serious health problem to important subgroups of the population which warranted its continued separate control. Thus, OAQPS does not recommend a joint SO_2/particles primary standard, believing that current information on health effects and U.S. exposures to these two pollutant categories warrants a continuation of separate controls.

CASAC concludes that separate SO_2 and particles standards, each set with appropriate consideration for potential interactions, does appear to protect public health. Furthermore, the complexities of setting and implementing a joint SO_2/particles standards through monitoring and other requirements create numerous uncertainties which the available scientific evidence is ill-equipped to resolve. CASAC concurs with the OAQPS position and its supporting rationale and recommends that you retain the current approach of setting separate primary and secondary standards for sulfur dioxide and particulate matter.

2. The scientific basis for a 24-hour standard stems primarily from epidemiological studies. These studies (Lawther et al. 1970 [analysis of bronchitics]; Martin and Bradley, 1960, Mazumdar et al., 1981, and Ware et al., 1981 [analysis of mortality]) do not show evidence of clear thresholds, but they suggest that risk to public health increases as concentration levels increase. The Air Quality Criteria Document for Sulfur Oxides/Particulate Matter and the SO_2 staff paper interpret these studies as suggesting that increases in excess mortality occurred in the range of 500–1000 $\mu g/m^3$ British Smoke and .19–.38 ppm SO_2, and that such effects are most likely when both pollutants exceeded 750 $\mu g/m^3$ (.29 ppm SO_2). Lawther's study of reported symptoms among bronchitics also suggests that this population group experiences significant responses associated with 24-hour averages of .19 ppm SO_2. Based upon these studies and the need for a margin of safety the staff paper developed a range of interest between .14 to .19 ppm in recommending a revised 24-hour primary SO_2 standard.

The upper end of the recommended range of .14 to .19 ppm represents a level at which effects are identified in the criteria document and for which there is little or no margin of safety for exposed sensitive individuals. You should be aware that the ranges of interest developed in the staff paper for the 24-hour standard were based on epidemiological studies which provided quantitative concentration/response data of the populations studied. A final decision on whether or not to revise the 24-hour standard should also incorporate information generated through controlled human, animal toxicology and the less quantitative epidemiology studies discussed in the criteria document and staff paper. In view of all of the above, CASAC recommends that you consider selecting a value at the lower end of the range for the 24-hour standard, taking into account whether a separate 1-hour primary standard is also established.

3. CASAC's review of the scientific evidence related to the annual primary standard presents a dilemma because the Committee could find no real quantitative basis for retaining this standard. This is a troublesome issue because there is the possibility that repeated SO_2 peaks of 1-hour and 24-hour exposures might lead to effects on human respiratory systems over the long-term. Second, an annual primary standard affords protection against health effects that can't be measured well in short-term controlled human studies. Third, air quality analysis conducted by OAQPS staff suggests that 1-hour and 24-hour primary standards in the range stated in the staff paper would not prevent SO_2 concentrations from exceeding the current annual primary standard in some heavily populated areas of the country. Fourth, as pointed out in the discussion of secondary standards, there is a scientific basis for a secondary standard at the level of the annual current primary standard. Following extended discussion the Committee concluded that some protection against chronic SO_2 exposures is needed, but that the most persuasive scientific basis for an annual standard is found in the effects on welfare.

4. The scientific basis for the development of a 1-hour primary standard rests largely on several major controlled human clinical studies conducted by three separate laboratories that were published in the peer reviewed literature in 1981 and 1982. These studies documented measurable changes in respiratory function of exercising asthmatics exposed for short periods at or below concentration levels of .50 parts per million (ppm). The studies (Kirkpatrick et al. 1982; Koenig et al. 1982; Linn et al. 1982; and Sheppard et al. 1981) raise the issue of how adequately the existing

primary standards are protecting public health and provide a scientific basis for a 1-hour primary standard that provides additional protection against such reported short-term effects.

The OAQPS staff, after reviewing this data, proposed consideration of a 1-hour primary standard in the range between .50 to .75 ppm. The staff noted that the lower end of the range represented the lowest level where potentially significant responses in asthmatics have been observed with oronasal breathing, and that the upper bound of the range represented levels at which the risk of significant functional and symptomatic responses in exposed asthmatics and other sensitive groups appeared high.

CASAC has evaluated the OAQPS staff position that resulted in the establishment of the range of interest at .50–.75 ppm. The staff suggests that there may be little or no margin of safety at the upper bound of the range. Air quality analyses conducted by OAQPS also indicate that a 1-hour standard selected from within the range would still permit exposures in excess of one to two ppm during the peak five or ten minute intervals. A related point is that establishment of a 24-hour standard in the range of .14–.19 ppm would not necessarily protect against shorter term peaks above the proposed 1-hour range of .50–.75 ppm. This information suggests that a 1-hour primary standard selected between .50–.75 ppm range might not adequately protect sensitive populations with an adequate margin of safety from the effects acknowledged in the staff paper that would occur as a result of brief peak exposures to concentrations greater than the .50–.75 ppm hourly average that a 1-hour standard would permit. Because five to ten minute peaks can reach levels as much as two or more times the 1-hour average, CASAC recommends that the range be modified to state the lower bound at .25 ppm.

In reviewing the issue of whether to establish a 1-hour primary standard between .25–.75 ppm several additional factors should be considered. These include (1) it is not clear that the reported effects experienced at or below .50 ppm are significant. The functional changes and symptoms reported in the .50–.75 ppm range appear to be reversible. You will need to determine which effects you consider to be adverse; (2) it is probable that some asthmatics are more sensitive than those who took part in the studies; (3) given current air quality conditions there is a low probability of exposure to exercising asthmatics at peak concentration levels; and (4) as the staff paper suggests, other stimuli interacting with SO_2, such as temperature and humidity, may increase the risk of an attack to exercising asthmatics more than either of these factors acting alone.

The Scientific Basis for Secondary SO_2 Standards

The kinds of effects reviewed by CASAC in relation to the establishment of secondary ambient air quality standards include those on vegetation, materials, and acidic deposition.

1. Current scientific information documents effects on vegetation resulting from both short-term and long-term exposures to SO_2 and/or SO_2 in combination with other pollutants. One should keep in mind that there is no single concentration at which all species of plants are injured, just as there is no single point or threshold at which all humans suffer significant effects from SO_2. What is at issue in the development of secondary standards is the need to protect sensitive vegetative species from effects such as physiological and biochemical changes, foliar injury, and reduced growth and yield. The available studies of SO_2 effects on vegetation represent approximately one percent of total plant species, but they include such important species as soybeans, barley, and white pine, to name a few.

An issue of increasing concern in the protection of vegetation is that SO_2 is not present alone in the ambient air except at a few isolated point sources. It almost invariably occurs in the presence of other pollutants, primarily nitrogen oxides and ozone. The scientific evidence is conclusive that the combination of such pollutants is more damaging to vegetation than the presence of SO_2 alone.

The staff paper recommends consideration of a 3-hour standard at or below the current secondary standard level of .50 ppm to protect vegetation. Although there are reports in the literature concerning plant injury at .10 to .20 ppm averaged over several hours, there are great uncertainties associated with the effects of the exposures at these lower levels. The existing data on the acute effects of SO_2 on vegetation suggest to CASAC that a concentration limit selected within a range of .40 to .50 ppm for a 3-hour period would provide adequate protection to sensitive vegetative species.

The review of longer term effects on plants was hampered by a very limited data base, thus making it difficult to distinguish whether such effects resulted from chronic lower-level exposures or a series of shorter-term peak exposures. Available data do suggest, however, that changes in species diversity and reduced growth in vascular plants are effects that may occur over the long term. In addition, non-vascular plants, particularly lichens and mosses, are affected by SO_2 during prolonged periods of exposure. On the basis of scientific work conducted to date, CASAC concurs with the OAQPS staff recommendation that an annual secondary standard at or below .03 ppm (a level equivalent to the existing annual primary SO_2 standard) would afford adequate protection to vascular plant vegetation. The basis for concern over effects in non-vascular plants at lower levels needs to be strengthened. CASAC also agrees with the staff proposal to address this issue in the context of later action on fine particles and acidic deposition.

2. The action of SO_2 alone or in combination with other pollutants has been associated with a number of damages to building materials, corrosion of ferrous and non-ferrous structures, and impairment of other goods and materials.

OAQPS staff have reviewed the evidence documenting materials damage from SO_2. These effects are responsible for economically significant losses which have been adequately summarized in both the criteria document and the staff paper. Analyses of existing air quality data by OAQPS indicate that continued protection against SO_2-induced materials damage is needed, and toward that end, the staff paper recommends consideration of a long-term SO_2 standard at or below the level of the existing annual primary standard (.03 ppm). CASAC concurs with the staff recommendation.

3. Throughout its review of both the Air Quality Criteria Document for Sulfur Oxides/Particulate Matter and the Staff Paper for Sulfur Oxides, CASAC has recognized the complexity of the acidic deposition problem. Since SO_2 is only one of the precursor pollutants that lead to the formation of acidic deposition, CASAC recommended in August 1980 that EPA prepare a separate Critical Assessment Document that recognizes and incorporates information on causes, effects and data bases for all of the various pollutants relevant to acidic deposition. This CASAC recommendation was accepted by two previous Administrators, Douglas Costle and Anne Burford, and the assessment document should be available for CASAC review in the near future. At that time the Committee will be in a position to provide a more comprehensive and critical assessment of the acidic deposition problem.

Re-affirmation of the Existing Primary and Secondary Standards

Throughout its review of the staff paper, CASAC recognizes that large uncertainties exist in the data that support development of the options for setting the standards discussed in the previous pages. Given these uncertainties CASAC discussed the extent to which the existing standards provide adequate protection to the public health. The Committee recognizes the substantial improvements in air quality that have occurred since the 1971 promulgation of the primary SO_2 standards. In addition, more information on the effects of the short-term SO_2 exposures should become available in the peer reviewed literature in the next few years. Air quality modeling analyses also suggest that attainment of the proposed 24-hour and annual standards would not ensure complete attainment of the proposed 1-hour primary standard at all sites within the ranges of interest stated. The reverse also appears to be true.

CASAC's evaluation of the scientific evidence associated with existing averaging times in the staff paper leads the Committee to conclude that continuation of the existing primary and secondary standards also provides protection against the effects identified in the criteria document and staff paper from SO_2 at ground level. If you choose to follow this option some CASAC members suggest that additional health protection can be obtained by converting the existing 3-hour secondary standard into a primary standard. A principal argument supporting the latter is that since the States are already implementing a 3-hour secondary standard, conversion to a 3-hour primary standard would not be impractical. In summary, in view of the many uncertainties that pertain to the review of the SO_2 standards, retention of the existing set of primary and secondary SO_2 standards is an option that you ought to seriously consider at the present time.

Conclusion

CASAC recognizes that your statutory responsibility to set standards requires public health policy judgments in addition to determinations of a strictly scientific nature. The submission of this closure letter completes the Committee's scientific assessment of this pollutant and we see no need to provide any additional formal comments on the standards prior to their proposal in the **Federal Register**. The public comment period will then provide sufficient opportunity for the Committee to provide any additional comment or review that may be necessary.

February 19, 1987.

The Honorable Lee M. Thomas,
Administrator, U.S. Environmental Protection Agency, Washington, DC 10460

Dear Mr. Thomas: The Clean Air Scientific Advisory Committee (CASAC) has completed its review of the 1986 Addendum to the 1982 Staff Paper on Sulfur Oxides (*Review of the National Ambient Air Quality Standards for Sulfur Oxides: Updated Assessment of Scientific and Technical Information*) prepared by the Agency's Office of Air Quality Planning and Standards (OAPQS).

The Committee unanimously concludes that this document is consistent in all significant respects with the scientific evidence presented and interpreted in the combined Air Quality Criteria Document for Particulate Matter/Sulfur Oxides (1982) and its 1986 Addendum, on which CASAC issued its closure letter on December 15, 1986. The Committee believes that the 1986 Addendum to the 1982 Staff Paper on Sulfur Oxides provides you with the kind and amount of technical guidance that will be needed to make appropriate decisions with respect to the standards. The Committee's major findings and conclusions concerning the various scientific issues and studies discussed in the Staff Paper Addendum are contained in the attached report.

Thank you for the opportunity to present the Committee's views on this important public health and welfare issue.

Sincerely,

Morton Lippmann, Ph.D.,
Chairman, Clean Air Scientific Advisory Committee.

cc: A. James Barnes
Gerald Emison
Lester Grant
Vaun Newill
John O'Connor
Craig Potter
Terry Yosie

Summary of Major Scientific Issues and CASAC Conclusions of the 1986 Draft Addendum to the 1982 Sulfur Oxides Staff Paper

The Committee found the technical discussions contained in the Staff Paper Addendum to be scientifically thorough and acceptable, subject to minor editorial revisions. This document is consistent in all significant respects with the scientific evidence presented in the 1982 combined Air Quality Criteria Document for Particulate Matter/Sulfur Oxides and its 1986 Addendum, on which the Committee issued its closure letter on December 15, 1986.

Scientific Basis for Primary Standards

The Committee addressed the scientific basis for a 1-hour, 24-hour, and annual primary standards at some length in its August 26, 1983 closure letter on the 1982 Sulfur Oxides Staff Paper. That letter was based on the scientific literature which had been published up to 1982. The present review has examined the more recently published studies.

It is clear that no single study of SO_2 can fully address the range of public health issues that arise during the standard setting process. The Agency has completed a thorough analysis of the strengths and weaknesses of various studies and has derived its recommended ranges of interest by evaluating the weight of the evidence. The Committee endorses this approach.

The Committee wishes to comment on several major issues concerning the scientific data that are available. These issues include:

- Recent studies more clearly implicate particulate matter than SO_2 as a longer-term public health concern at low exposure levels.
- A majority of Committee members believe that the effects reported in the clinical studies of asthmatics represent effects of significant public health concern.
- The exposure uncertainties associated with a 1-hour standard are quite large. The relationship between the frequency of short-term peak exposures and various scenarios of asthmatic responses is not well understood. Both EPA and the electric power industry are conducting further analyses of a series of exposure assessment issues. Such analyses have the potential to increase the collective understanding of the relationship between SO_2 exposures and responses observed in subgroups of the general population.
- The number of asthmatics vulnerable to peak exposures near electric power plants, given the protection afforded by the current standards, represents a small number of people. Although the Clean Air Act requires that sensitive population groups receive protection, the size of such groups has not been defined. CASAC believes that this issue represents a legal/policy matter and has no specific scientific advice to provide on it.

CASAC's advice on primary standards for three averaging times is presented below:

1-Hour Standard—It is our conclusion that a large, consistent data base exists to document the bronchoconstrictive response in mild to moderate asthmatics subjected in clinical chambers to short-term low levels of sulfur dioxide while exercising. There is, however, no

scientific basis at present to support or dispute the hypothesis that individuals participating in the SO_2 clinical studies are surrogates for more sensitive asthmatics. Estimates of the size of the asthmatic population that experience exposures to short-term peaks of SO_2 (0.2–0.4 parts per million (ppm) SO_2 for 5–10 minutes) during light to moderate exercise, and that can be expected to exhibit a bronchoconstrictive response, varies from 5,000 to 50,000.

The majority of the Committee believes that the scientific evidence supporting the establishment of a new 1-hour standard is stronger than it was in 1983. As a result, and in view of the significance of the effects reported in these clinical studies, there is strong, but not unanimous support for the recommendation that the Administrator consider establishing a new 1-hour standard for SO_2 exposures. The Committee agrees that the range suggested by EPA staff (0.2–0.5 ppm) is appropriate, with several members of the Committee suggesting a standard from the middle of this range. The Committee concludes that there is not a scientifically demonstrated need for a wide margin of safety for a 1-hour standard.

24-Hour Standard—The more recent studies presented and analyzed in the 1986 Staff Paper Addendum, in particular, the episodic lung function studies in children (Dockery et al., and Dassen et al.) serve to strengthen our previous conclusion that the rationale for reaffirming the 24-hour standard is appropriate.

Annual Standard—The Committee reaffirms its conclusion, voiced in its 1983 closure letter, that there is no quantitative basis for retaining the current annual standard. However, a decision to abolish the annual standard must be considered in the light of the total protection that is to be offered by the suite of standards that will be established.

The above recommendations reflect the consensus position of CASAC. Not all CASAC reviewers agree with each position adopted because of the uncertainties associated with the existing scientific data. However, a strong majority supports each of the specific recommendations presented above, and the entire Committee agrees that this letter represents the consensus position.

Secondary Standards

The 3-hour secondary standard was not addressed at this review.

Addendum III—Executive Summary of the 1986 Addendum to the OAQPS Staff Paper on Sulfur Oxides

Executive Summary

This paper evalutes and interprets the updated scientific and technical information that the EPA staff believes is most relevant to the review of primary (health) national ambient air quality standards (NAAQS) for sulfur oxides [1] and represents an update of the 1982 sulfure oxides staff paper. This paper assesses what the staff believes should be considered in selecting appropriate averaging times and levels for the primary sulfur oxides standards, updating and supplementing previous staff conclusions and recommendations in these areas to incorporate more recent information. The assessment in this staff paper addendum is intended to help bridge the gap between the scientific review contained in the EPA criteria document addendum "Second Addendum Air Quality Criteria for Particulate Matter and Sulfur Oxides (1982): Assessment of Newly Available Health Effects Information" and the judgments required of the Administrator in setting ambient standards for sulfur oxides. The staff paper and this addendum are, therefore, an important element in the standards review process and provide an opportunity for public comment on proposed staff recommendations before they are presented to the Administrator. The focus of this paper is on sulfur dioxide (SO_2), alone and in combination with other pollutants.

SO_2 is a rapidly diffusing reactive gas that is quite soluble in water. It is emitted principally from combustion or processing of sulfur-containing fossil fuels and ores. SO_2 occurs in the atmosphere with a variety of particles and other gases, and undergoes chemical and physical interactions with them forming sulfates and other transformation products.

Because much of the recently available health effects information on SO_2 is related to short-term exposures, the staff paid particular attention to updating information on short-term peak concentrations. The staff found that:

(1) Maximum 5 minute to hourly SO_2 concentrations are found near major point sources. The newer information tends to support earlier conclusions that near such sources, the 5 to 10 minute peak SO_2 concentration is likely to be within a factor of 1.4 to 2.4 times the hourly average. Maximum peak to mean ratios can be higher.

(2) Short duration peaks (less than 30 seconds to 2 minutes) in excess of 0.5 ppm appear likely to occur near numerous smaller sources of SO_2. None of the recently published assessments of the health effects of SO_2 has addressed exposures of such limited duration. Due to limitations of the monitoring instruments, it is not presently possible to assess the extent to which such peaks may be occurring in particular urban locations.

Updated Assessment of the Primary Standards

Conclusions and recommendations based on the updated staff assessment of the information in the criteria document addendum are summarized below.

(1) The present staff assessment of the more recent studies reinforce the earlier conclusion reached in the 1982 staff assessment that the most striking acute response to SO_2 is reflex bronchoconstriction, or airway narrowing, in exercising asthmatics and others with hyperreactive airways.

(2)(a) The updated staff assessment of key controlled human studies of peak (minutes to an hour) SO_2 exposures is summarized in Table 1. Both recently published studies and those assessed in the 1982 staff paper are included. The table focuses on those studies involving free breathing (chamber) or facemask exposures, which provide the closest approximation of natural breathing. After account is made for differences in ventilation rates and oral/nasal breathing patterns, consistent results are derived from the various studies including even those that used mouthpiece exposures. The major effects observed in these studies are increases in airway resistance and decreases in other functional measures indicative of significant bronchoconstriction in sensitive asthmatic or atopic subjects. At 0.4 ppm SO_2, changes in functional measures are accompanied by mild increases in perceptible symptoms such as wheezing, chest tightness, and coughing. At higher concentrations, effects are more pronounced and the fraction of asthmatic subjects who respond increase, with clearer indications of clinically or physiologically significant effects at 0.6–0.75 ppm and above.

[1] The current standards for sulfur dioxide (SO_2) are: primary, 0.03 ppm (80$\mu g/m^3$) annual arithmetic mean and 0.14 ppm (365 $\mu g/m^3$) 24-hour average not to be exceeded more than once per year; and, secondary, 0.5 ppm (1300 $\mu g/m^3$) 3-hour average not to be exceeded more than once per year.

TABLE 1.—UPDATED STAFF ASSESSMENT OF KEY CONTROLLED HUMAN STUDIES

SO_2 concentration (5–60 minutes)	Observed effects [1]	Comments/implications
1–2 ppm	Substantial changes in 8 of 12 subjects (ΔSRaw 100–600%) exposed to 2 ppm. At 1 ppm, functional changes (ΔSRaw 170–200%), symptoms in free breathing asthmatics at moderate exercise [2].	Effects range from moderate to incapacitating for some individuals. At 2 ppm, 80% of mild asthmatics could experience at least a doubling of SRaw. Some might not tolerate exposure at moderate exercise. Approx. 60% at 1 ppm could experience at least a doubling of SRaw.[3] Some asthmatic mouth breathers have significant bronchoconstriction at 2 ppm, even at light activity.
0.6–0.75 ppm	Functional changes (ΔSRaw 120–260%), symptoms in free breathing asthmatics at light-moderate exercise [4].	Effects indicative of clininal significance; on average, changes were mild to moderate although severe for some individuals; 25–50% of mild, free-breathing asthmatics at moderate exercise could experience at least a doubling of airway resistance.[3]
0.5 ppm	Significant functional changes (ΔSRaw 50–100%), symptoms in free breathing asthmatics at moderate, but not at light exercise.[5] At heavy exercise, ΔSRaw, 220–240%.[6].	On average, mild responses at moderate or higher exercise, symptoms possibly of clinical significance; severe responses for some individuals. About 20–25% could experience at least a doubling in airway resistance.
0.4 ppm	Functional changes (ΔSRaw 70%), symptoms in free breathing asthmatics at moderate-heavy exercise [7].	Lowest level of clinically significant response for some free breathers. Approx. 10% of mild, free breathing asthmatics could experience a doubling in airway resistance.[3]
0.1–0.3 ppm	No effects in free breathing asthmatics at light exercise. Slight but not significant functional changes in free-breathing subjects at moderate-heavy exercise (0.25 ppm) [6], but not at lower levels.[7].	Significant effects unlikely at moderate exercise. Effects of SO_2 indistinguishable at heavy exercise. Possibility of more significant responses in small percentage of sensitive asthmatics at 0.28 ppm.[3]

[1] Specific Airway Resistance (SRaw) is the lung function measure most often reported in SO_2 studies. Unless otherwise noted, (ΔSRaw_____(%) reflects group mean increase over clean air control at rest. Light, moderate, heavy exercise refers to ventilation rates approximating ≤35 L/min, 40–45 L/min, and ≥ 50 L/min, respectively. Effects reflect results from range of moderate temperature/humidity conditions (i.e., 7–26°C, 36–90% RH). Studies at 0.5–0.6 ppm indicate that exercise-induced bronchoconstriction associated with cold and/or dry air exacerbates response to SO_2 while warm, humid air mitigates asthmatic responses relative to moderate conditions.

[2] Schacter et al. (1984); Roger et al. (1985); Horstman et al. (1986).

[3] Horstman et al., (1986).

[4] Hackney et al. (1984); Schacter et al. (1984); Linn et al. (1983a, b, 1984a, b, c, 1985a).

[5] Kirkpatrick et al. (1982); Linn et al. (1984b); Roger et al. (1985); Schacter et al. (1984).

[6] Bethel et al. (1983a, b; 1985).

[7] Linn et al. (1983b, 1984a).

(b) Significant bronchconstriction has been observed in asthmatics after 5–10 minutes of exposure and usually diminishes within one hour once either exposure or exercise alone is discontinued. Responses are mitigated with repeated exposures within one hour but not with continuous exposure, nor with subsequent exposures 5–24 hours later. Recent work indicates that the combined effect of SO_2 and cold, dry air further exacerbates the asthmatic response while warm, humid conditions mitigate SO_2 effects.

(c) Given practical considerations related to monitoring, modeling, data manipulation and storage, and implementation, the staff previously recommended consideration of a 1-hour averaging time to protect against the responses to short-term peak (5–10 minute) SO_2 exposures observed in the controlled human studies. Based on this updated staff assessment, the range of potential 1-hour levels of interest is revised from 0.25 to 0.75 ppm to 0.2 to 0.5 ppm (525 to 1300 $\mu g/m^3$). The lower bound represents a 1-hour level for which the maximum 5 to 10 minute peak exposures are unlikely to exceed 0.4 ppm, which is the lowest level where potentially significant responses in free (oronasal) breathing asthmatics have been reported in the criteria document addendum.The upper bound of the range represents a 1-hour level for which 5 to 10 minute peak concentration are unlikely to exceed 1 ppm, a concentration at which the risk of significant functional and symptomatic responses in exposed sensitive asthmatics and atopics appears high. In evaluating these laboratory data in the context of decision making on possible 1-hour standards, the following considerations are important: (a) The significance of the observed or anticipated responses to health, (b) the relative effect of SO_2 compared to normal day to day variations in asthmatics from exercise and other stimuli, (c) the low probability of exposures of exercising asthmatics to peak levels, and (d) five to ten minute peak exposures may be a factor of two greater than hourly averages.

(d) Independent of frequency of exposure considerations, the upper bound of the range contains little or no margin of safety for exposed sensitive individuals. The limited geographical areas likely to be affected and low frequency of peak exposures to active asthmatics if the standard is met add to the margin of safety. The widespread use of medication among asthmatics that prevents or rapidly relieves bronchoconstrictive effects due to natural and commonly encountered stimuli (e.g., exercise, cold air) further adds to the margin of safety. The data do not suggest other groups that are more sensitive than asthmatics to single peak exposures, but qualitative data suggest repeated peaks might produce effects of concern in other sensitive individuals. Potential interactions of SO_2 and O_3 have not been investigated in asthmatics. The qualitative data, potential pollution interactions, and other considerations listed above should be considered in determining the need for and evaluating the margin of safety provided by alternative 1–hour standards.

(3) Based on a staff assessment of the recent short-term epidemiological data summarized in Table 2, the original staff range of 24-hour SO_2 levels of interst—0.14 to 0.19 ppm (365 to 500 $\mu g/m^3$)—still appears appropriate, although some consideration could be given to the findings of physiological changes of uncertain significance at levels as low as 0.1 ppm. Earlier staff conclusions and recommendations concerning retaining the present 24-hour standard remain appropriate.

TABLE 2.—UPDATED STAFF ASSESSMENT OF SHORT-TERM EPIDEMIOLOGICAL STUDIES

Effects/study	Measured SO_2-$\mu g/m^3$ (ppm)—24 hour mean			
	Daily mortality in London [1]	Aggravation of bronchitis [2]	Small, reversible declines in children's lung function [3]	Combined effects levels
Effects likely	500–1000 (0.19–0.38)	500–600 (0.19–0.23)		500 (0.19)
Effects possible		<500 (0.19)	250–450 (0.10–0.18)	250 (0.10)
No effects observed			100–200 (0.04–0.08)	<200 (.08)

[1] Deviations in dailyn mortality during London winters (1958–1972). Early winters dominated by high smoke and SO_2, principally from coal combustion emissions, and with frequent fogs (Martin and Bradley, 1960; Ware et al., 1981; Mazumdar et al., 1981, 1982; Schwartz and Marcus, 1986).
[2] Examination of symptoms reported by bronchitics in London. Studies conducted from the mid-1950's to early 1970's (Lawther et al., 1970).
[3] Studies of children in Steubenville (1978–80) and in the Netherlands (1985–86) before, during, and after pollution episodes characterized by high particle and SO_2 levels (Dockery et al., 1982; Dassen et al., 1986).

(4) The previous staff assessment concluded that although the possibility of effects from continuous lower level exposures to SO_2 cannot be ruled out, no quantitative rationale could be offered to support a specific range of interest for an annual standard. The more recent epidemiological data, indicating associations between respiratory illnesses and symptoms and persistent exposures to SO_2 in areas with long-term averages exceeding .04 ppm (100 $\mu g/m^3$), provide additional support for the original recommendation for retaining an annual standard at or near the current level of 0.03 ppm (80 $\mu g/m^3$). This recommendation was based in part on finding that alternative short-term standards (1, 3, and 24-hour) would not prevent annual levels in excess of the current standard in a limited number of heavily populated urban areas. In addition, recent evidence suggests smaller sources in urban areas may produce short duration (<1 minute) peaks of potential concern. The long-term standard often serves to limit the emissions of numerous smaller sources in such areas. Given the additional information and the possibility of both chronic and acute effects from a large increase in population exposure, the staff recommends maintaining the primary annual standard at its current level.

(5) Analyses of alternative averaging times and population exposures suggest that:

(a) The current standards provide substantial protection against the effects identified as being associated with 24 hour and annual exposures.

(b) The current standards—as reflected by current emissions or emissions when the standards are just met with somewhat less restrictive implementation assumptions—also provide some limit on peak SO_2 exposures of concern for asthmatics. In some cases, however, up to 1 to 14% of the sensitive population in the vicinity of major sources could be exposed once a year to levels at or above 0.5 ppm for 5 minutes, while at elevated ventilation.

(c) The range of 1-hour standards analyzed (0.25 to 0.5 ppm) provides increased protection against such exposures, limiting the fraction of asthmatics exposed living near certain major point sources to less than 4%, although very short-term (<2 minutes) exposures greater than 0.5 ppm around smaller facilities would not be eliminated.

The relative protection afforded by current vs. alternative standards as indicated by current and ongoing exposure analyses is an important consideration in determining what, if any, standard revisions may be necessary.

For reasons set forth in the preamble, EPA proposes to amend Part 50, Chapter I of Title 40 of the *Code of Federal Regulations* as follows:

PART 50—NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS

1. The authority citation for Part 50 continues to read as follows:

Authority: Sections 109 and 301(a), Clean Air Act, as amended (42 U.S.C. 7409, 7601(a)).

2. Section 50.4 is revised to read as follows:

§ 50.4 National primary ambient air quality standards for sulfur oxides (sulfur dioxide).

(a) The level of the annual standard is 0.030 parts per million (ppm) (80 $\mu g/m^3$). The standard is attained when the annual arithmetic mean concentration in a calendar year is less than or equal to 0.030 ppm, rounded to three decimal places (fractional parts equal to or greater than 0.0005 ppm must be rounded up).

(b) The level of the 24-hour standard is 0.14 parts per million (ppm) (365 $\mu g/m^3$). The standard is attained when the second highest 24-hour average in a calendar year is less than or equal to 0.14 ppm, rounded to two decimal places (fractional parts equal to or greater than 0.005 ppm must be rounded up). The 24-hour averages shall be determined from successive nonoverlapping 24-hour blocks starting at midnight each calendar day.

(c) Sulfur oxides shall be measured in the ambient air as sulfur dioxide by the reference method described in Appendix A to this part or by an equivalent method designated in accordance with Part 53 of this chapter.

(d) To demonstrate attainment, the annual arithmetic mean and the second-highest 24-hour averages must be based upon hourly data that are at least 75 percent complete in each calendar quarter. A 24-hour block average shall be considered valid if at least 75 percent of the hourly averages for the 24-hour period are available. In the event that only 18, 19, 20, 21, 22 or 23 hourly averages are available, the 24-hour block average shall be computed as the sum of the available hourly averages using 18, 19, etc. as the divisor. If less than 18 hourly averages are available, but the 24-hour average would exceed the level of the standard when zeros are substituted for the missing values, subject to the rounding rule of paragraph (b) of this section, then this shall be considered a valid 24-hour average. In this case, the 24-hour block average shall be computed as the sum of the available hourly averages divided by 24.

3. Section 50.5 is revised to read as follows:

§ 50.5 National secondary ambient air quality standard for sulfur oxides (sulfur dioxide).

(a) The level of the 3-hour standard is 0.5 parts per million (ppm) (1300 $\mu g/m^3$). The standard is attained when the second-highest 3-hour average in a calendar year is less than or equal to 0.5 ppm, rounded to 1 decimal place (fractional parts equal to or greater than 0.05 ppm must be rounded up). The 3-hour averages shall be determined from successive nonoverlapping 3-hour blocks starting at midnight each calendar day.

(b) Sulfur oxides shall be measured in the ambient air as sulfur dioxide by the reference method described in Appendix A to this part or by an equivalent method designated in accordance with Part 53 of this chapter.

(c) To demonstrate attainment, the second-highest 3-hour average must be based upon hourly data that are at least 75 percent complete in each calendar quarter. A 3-hour block average shall be considered valid only if all three hourly averages for the 3-hour period are available. If only one or two hourly averages are available, but the 3-hour average would exceed the level of the standard when zeros are substituted for the missing values, subject to the rounding rule of paragraph (a) of this section, then this shall be considered a valid 3-hour average. In all cases, the 3-hour block average shall be computed as the sum of the hourly averages divided by 3.

For reasons set out in the preamble, Part 51 of Chapter I of Title 40 of the Code of Federal Regulations is proposed to be amended as follows:

PART 51—REQUIREMENTS FOR PREPARATION, ADOPTION, AND SUBMITTAL OF IMPLEMENTATION PLANS

1. The authority for Part 51 continues to read as follows:

Authority: Sec. 301(a), Clean Air Act (42 U.S.C. 1857(a)), as amended by section 15(c)(2), Pub. L. 91-604, 84 Stat. 1713, unless otherwise noted.

2. In § 51.151 of Subpart H, the entry for "sulfur dioxide" is revised to read as follows:

§ 51.151 Significant harm levels.

* * * * *

Sulfur dioxide—5.0 parts per million (13000 micrograms/cubic meter), 5-minute average; 2.5 parts per million (6550 micrograms/cubic meter), 1-hour average, as a guide to be used in assessing contingency plans to prevent exceedances of the 5-minute significant harm level; 0.29 parts per million (750 micrograms/cubic meter), 24-hour average.

* * * * *

3. In Appendix L, paragraphs 1.1 (b), (c), and (d) are amended by revising the entries for "SO_2" to read as follows:

Appendix L—Example Regulations for Prevention of Air Pollution Emergency Episodes

1.1 * * *

(b) * * *

SO_2—0.75 ppm (1960 $\mu g/m^3$), 1-hour average; 0.19 ppm (500 $\mu g/m^3$), 24-hour average.

* * * * *

(c) * * *

SO_2—1.0 ppm (2620 $\mu g/m^3$), 1-hour average; 0.23 ppm (600 $\mu g/m^3$), 24-hour average.

* * * * *

(d) * * *

SO_2—1.5 ppm (3930 $\mu g/m^3$), 1-hour average; 0.26 ppm (675 $\mu g/m^3$), 24-hour average.

* * * * *

For the reasons set out in the preamble, Part 58 of Chapter I of Title 40 of the Code of Federal Regulations is proposed to be amended as follows:

PART 58—AMBIENT AIR QUALITY SURVEILLANCE

1. The authority for Part 58 continues to read as follows:

Authority: 42 U.S.C. 7410, 7601(a), 7619.

2. Appendix C is proposed to be amended by adding Section 2.4 to read as follows:

Appendix C—Ambient Air Quality Monitoring Methodology

* * * * *

2.4 Analyzer Measurement Range. Except as otherwise provided in this Appendix, automated methods (analyzers) used in a SLAMS must be operated with a measurement range approved as part of the analyzer's designation as a reference or equivalent method. The nominal ranges, specified in Table B-1 of Part 53 of this Chapter, are 0-0.5 ppm for SO_2, NO_2, and O_3 analyzers and 0-50 ppm for CO analyzers. Narrower (lower) ranges, or broader (higher) ranges extending to not more than two times the upper range limit specified in Table B-1 of Part 53 of this Chapter (i.e., 0-1 ppm for SO_2, NO_2, and O_3 analyzers and 0-100 ppm for CO analyzers), may be used if approved as part of the analyzer's designation. Generally, a SLAMS analyzer should be operated on the lowest (narrowest) approved range that will include and accurately measure the highest pollutant concentration likely to occur at the monitoring site during a specified monitoring period. If concentrations can be expected to exceed 1 ppm (SO_2, NO_2, O_3) or 100 ppm for CO, application for use of non-conforming ranges must be filed following the provisions of Section 2.6 of this Appendix.

* * * * *

3. Appendix F, sections 2.1.1 and 2.1.2 introductory text are revised to read as follows:

Appendix F—Annual SLAMS Air Quality Information

* * * * *

2.1.1 Site and Monitoring Information. City name (when applicable), county name and street address of site location. SAROAD site code. SAROAD monitoring method code. Number of hourly observations for continuous methods only. Number of daily observations for manual or intermittent methods only.

2.1.2 Annual Summary Statistics. Annual arithmetic mean (ppm). Highest and second highest 24-hour averages (ppm) and dates of occurrence, based on fixed block (midnight to midnight) averages. Highest and second highest 3-hour averages (ppm) and dates and times (ending hour) of occurrence for continuous methods based on eight fixed block (midnight to 3:00 a.m., 3:00 to 6:00 a.m., etc.) averages per day. Number of exceedances of the 24-hour primary NAAQS based on fixed block averages. Number of exceedances of the 3-hour secondary NAAQS based on the eight fixed block averages. Number of 24-hour (midnight to midnight) average concentrations in ranges:

* * * * *

Appendix G [Amended]

4. Appendix G is amended as follows:

a. In 7.2:

i. The heading is revised to read "7.2 Example Computations"

ii. The heading, *Example A.* is added before the word "Suppose" in the first paragraph.

iii. After the second paragraph ending with "exceed 80", a second example, Example B, is added as follows:

Example B. In the of SO_2, there are two subindex functions—one for 24-hour running averages and one for 1-hour averages. At the time a PSI report is to be issued, suppose an SO_2 24-hour running average of .15 ppm is observed, and a 1-hour concentration of 0.80 ppm is also observed. The PSI subindex functions would be computed for both averaging times. Based on the breakpoints in Table 2, the corresponding PSI index value for the 24-hour running averages is 120, while the PSI value for the 1-hour value is 220. In this case, the maximum PSI value of 220 would be used for SO_2. If the other pollutant subindices were $I_2=0$, $I_3=0$, $I_4=20$ and $I_5=30$, then the overall index is reported as the maximum of these values:

$PSI=\max(220, 0, 0, 20, 30)=220$

In this example, if the 1-hour average concentration were 0.70 ppm instead of 0.80 ppm, there would be no PSI subindex value for the 1-hour value because the PSI subindex function is not used unless the SO_2 1-hour concentration is greater than or equal to 0.75 ppm (1965 ug/m^3). As a result, the maximum PSI index value would be the 120 value recorded for the 24-hour average of 0.15 ppm, which in this example would also be the overall index for the day.

b. In Table 1, the second column entitled 24-hour SO_2 ug/m^3 is revised and an additional column is inserted next to it entitled, 1-hour SO_2 ug/m^3 to read as follows:

TABLE 1.—BREAKPOINT FOR PSI IN METRIC UNITS [1]

24-hr SO_2 ug/m^3	1-hour SO_2 ug/m^3
80[3]	(*)
365[3]	(*)

TABLE 1.—BREAKPOINT FOR PSI IN METRIC UNITS [1]—Continued

500[3]	1965[3]
600[3]	2620[3]
675[3]	3930[3]
750[3]	6550[3]

[1] At 25°C and 760 mm Hg.
[3] All the concentration levels are used for illustrative purposes only. The actual levels will be determined at the time of the promulgation of the standard.
[4] No index value reported at these concentrations because there is no 1-hour NAAQS for SO_2.

c. In Table 2, the first column entitled 24-hour SO_2 ppm is revised and an additional column is inserted next to it entitled one 1-hour SO_2 ppm to read as follows:

TABLE 2.—BREAKPOINTS FOR PSI

[Parts per million]

24-hour SO_2	1-hour SO_2
0.03[2]	([1])
0.14[2]	([1])
0.19[2]	0.75[2]
0.23[2]	1.00[2]
0.26[2]	1.50[2]
0.29[2]	2.50[2]

[1] No index value reported at these concentration levels because there is no short-term NAAQS.
[2] All the concentration levels are used for illustrative purposes only. The actual levels will be determined at the time of the promulgation of the standard.

d. Figure 3 is removed and Figure 3A (24-hour SO_2 running averages) and Figure 3b (1-hour SO_2 averages) are added:

BILLING CODE 6560-50-M

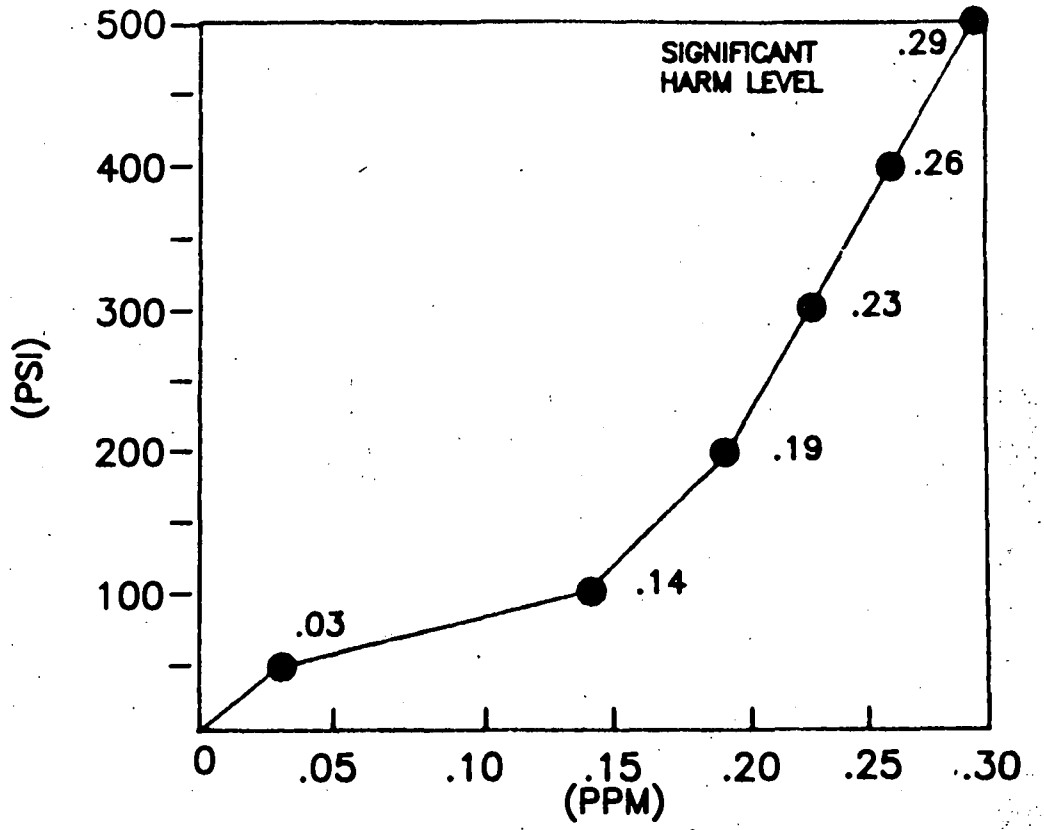

Figure 3a – PSI FUNCTION FOR SULFUR DIOXIDE (24 HOUR RUNNING AVERAGE)

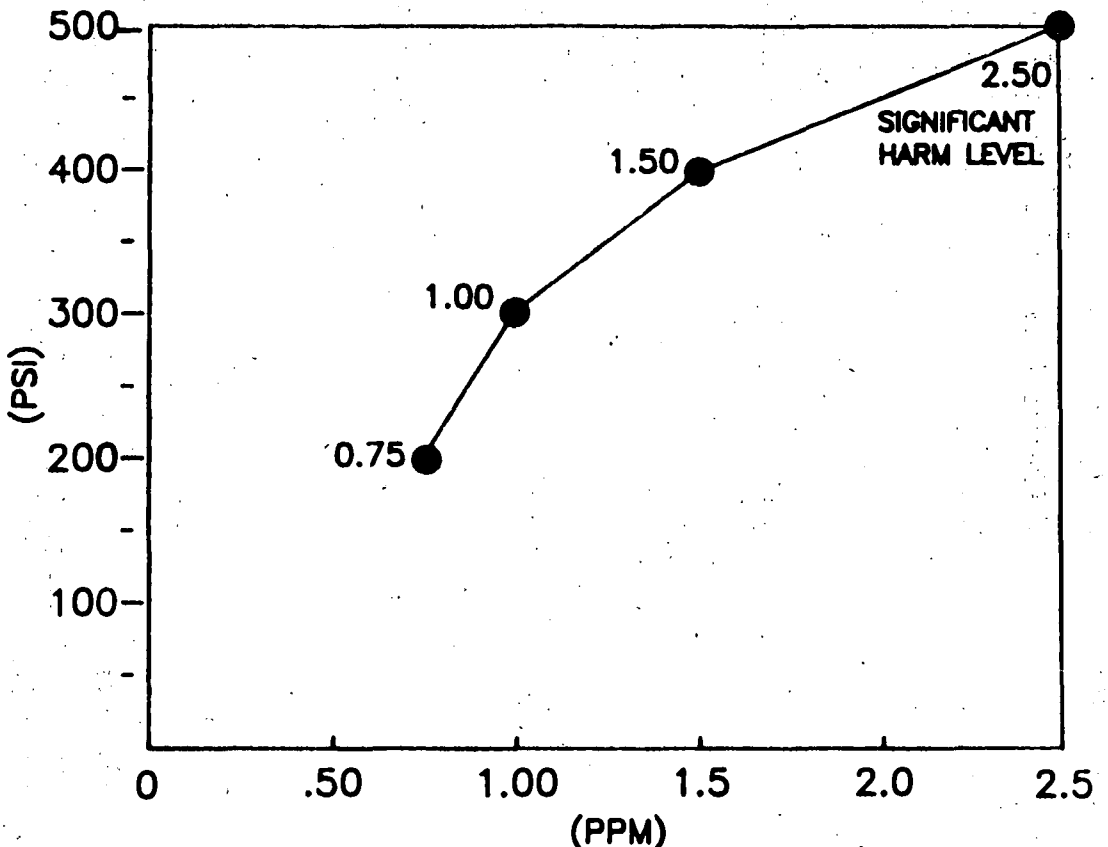

FIGURE 3b – PSI FUNCTION FOR SULFUR DIOXIDE (1–HOUR AVERAGE)

[FR Doc. 88–8741 Filed 4–25–88; 8:45 am]
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