[6560-01-M]

Title 40—Protection of Environment

CHAPTER I—ENVIRONMENTAL PROTECTION AGENCY

SUBCHAPTER C—AIR PROGRAMS

[FRL 1018-2]

PART 50—NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS

Revisions to the National Ambient Air Quality Standards for Photochemical Oxidants

AGENCY: Environmental Protection Agency.

ACTION: Final rulemaking.

SUMMARY: In accordance with the provisions of Sections 108 and 109 of the Clean Air Act as amended, EPA has reviewed and revised the criteria upon which the existing primary and secondary photochemical oxidant standards are based. These standards were promulgated in 1971 (36 FR 8186) and were both set at an hourly average level of 0.08 part per million (ppm) not to be exceeded more than 1 hour per year. On June 22, 1978, EPA proposed changes in the standard (43 FR 26962) based on the findings of the revised criteria. The proposed changes included (1) raising the primary standard to 0.10 ppm, (2) retaining the 0.08 ppm secondary standard, (3) changing the chemical designation of the standard from photochemical oxidants to ozone, and (4) changing to a standard with a statistical rather than deterministic form. The final rulemaking will make three further changes in the standard: (1) Raising the primary standard to 0.12 ppm, (2) raising the secondary standard to 0.12 ppm, and (3) changing the definition of the point at which the standard is attained to "when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than one."

EFFECTIVE DATE: This revision is effective immediately upon publication. The normal 30-day delay in effectiveness is not required, when, as in this case, a restriction is eased.

FOR FURTHER INFORMATION CONTACT:

Mr. Joseph Padgett, Director (MD-12), Strategies and Air Standards Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711, Telephone: 919-541-5204 (FTS 629-5204.

AVAILABILITY OF RELATED INFORMATION: A docket (Number OAQPS 78-8) containing information used by EPA in revising the standards is available for public inspection and copying between 8:00 a.m. and 4:30 p.m. Monday through Friday, at EPA's Central Docket Section, Room 2903 Waterside Mall, 401 M Street SW, Washington DC 20460. These materials include the "Air Quality Criteria for Ozone and Other Photochemical Oxidants" and "Control Techniques for Volatile Organic Emissions from Stationary Sources," both of which were issued simultaneously when this standard was proposed. The control techniques document and staff papers pertaining to the form of the ozone standard, risk assessment method, secondary standard, and health panel assessment are available upon request from Mr. Joseph Padgett. Statements of the environmental, economic, and energy impacts of implementing this standard revision are also available upon request from Mr. Joseph Padgett, at the address shown above. The air quality criteria document can be obtained from: Mr. Michael Berry (MD-52), Environmental Criteria and Assessment Office, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711, Telephone: 919-541-2266 (FTS 629-2266).

This preamble describes revisions to 40 CFR Part 50, Appendix H, "Interpretation of the National Ambient Air Quality Standards for Ozone," and Appendix D, "Measurement Principle and Calibration Procedure for the Measurement of Photochemical Oxidants Corrected for Interferences Due to Nitrogen Oxides and Sulfur Dioxide," that are related to the revision of the air quality standard for ozone. In addition, elsewhere in this issue of the FEDERAL REGISTER EPA is promulgating revisions to 40 CFR Part 50, Appendix D, replacing (superseding) the current calibration procedure with a new, superior calibration procedure based on ultraviolet photometry.

Revisions to 40 CFR Part 51, substituting the word "ozone" for "photochemical oxidants" throughout that part, and to Section 51.14, pertaining to control strategies, are being promulgated by EPA elsewhere in this issue of the FEDERAL REGISTER.

SUPPLEMENTARY INFORMATION:

BACKGROUND

On April 30, 1971, the Environmental Protection Agency promulgated in the FEDERAL REGISTER (36 FR 8186) National Ambient Air Quality Standards for photochemical oxidants. The scientific, technical, and medical bases for these standards are contained in the air quality criteria document for photochemical oxidants, published by the U.S. Department of Health, Education, and Welfare in March 1970. Both the primary and secondary standards were set at an hourly average level of 0.08 ppm not to be exceeded more than once per year. The asthma study cited as evidence for the original standard is based on work by Schoettlin and Landau (1961). As discussed in the June 22, 1978, proposed revision to the original standard, EPA has reassessed its conclusions regarding this study. This reassessment, plus the evaluation of medical evidence accumulated since 1970, led EPA to propose, on June 22, 1978, a revised primary standard of 0.10 ppm (43 FR 26962). EPA did not propose a change in the secondary welfare standard at that time. The proposal was accompanied by publication of revised criteria and control techniques documents, as well as various staff papers relating to the standard itself and to implementation of the standard. EPA solicited written comments on the proposed standard and, to accept oral testimony, sponsored four public hearings (Washington, D C.—July 18; Altanta, Ga.—August 17; Dallas, Tex.—August 22; Los Angeles, Calif.—August 24).

Oxidants are strongly oxidizing compounds, which are the primary constituents of photochemical smog. The oxidant found in largest amounts is ozone (O_3), a very reactive form of oxygen. Oxidants also include the group of compounds referred to collectively as peroxyacylnitrates (PANs) and other compounds, all produced in much smaller quantities than ozone.

Most of these materials are not emitted directly into the atmosphere but result primarily from a series of chemical reactions between oxidant precursors (nitrogen oxides and organic compounds) in the presence of sunlight. The principal sources of organic compounds are the hydrocarbon emissions from automobile and truck exhausts, gasoline vapors, paint solvent evaporation, open burning, dry cleaning fluids, chemical plants and other industrial operations. Nitrogen oxides are emitted primarily from combustion sources such as electric power generation units, gas and oil-fired space heaters, and automobile, diesel and jet engines.

The reductions in emissions of nitrogen oxides and organic compounds are achieved through Federal and State programs that have been formalized in regulations promulgated under the Clean Air Act. The Federal programs provide for reduction in emissions nationwide through the Federal Motor Vehicle Control Program, the Federal program for control of aircraft emissions, National Emission Standards for Hazardous Air Pollutants, and the development of New Source Performance Standards. The State programs provide for additional control measures through State Implementation Plans in those areas of the country where the Federal programs are not sufficiently stringent to permit attainment of air quality standards.

LEGISLATIVE REQUIREMENTS AFFECTING THIS PROMULGATION

Two sections of the Clean Air Act govern the development of a National Ambient Air Quality Standard: Section 108 instructs EPA to document the scientific basis (criteria) for the standard, and Section 109 provides guidance on establishing standards and reviewing the criteria.

Air quality criteria are required by Section 108(a)(2) to reflect accurately the latest scientific information useful in indicating the kind and extent of all identifiable effects on public health or welfare that may be expected from the presence of the pollutant in the ambient air.

The Administrator is required to propose, simultaneously with the issuance of these criteria, primary and secondary ambient air quality standards based upon such criteria. The primary standard is defined in Section 109(b)(1) as the ambient air quality standard the attainment and maintenance of which in the Administrator's judgment, based on such criteria and allowing an adequate margin of safety, are requisite to protect the public health. The secondary standard (Section 109(b)(2)) must specify a level the attainment and maintenance of which in the Administrator's judgment, based on such criteria, are requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of the pollutant in the ambient air. These adverse welfare effects, which are discussed in Section 302(h) of the Act, include effects on soils, water, crops, vegetation, man-made materials, animals, weather, visibility, hazards to transportation, economic values, personal comfort and well-being, and other factors.

The Clean Air Act specifies that primary National Ambient Air Quality Standards are to be based on scientific criteria relating to the level that should be attained to protect public health adequately. Considerations of cost of achieving those standards or the existence of technology to bring about needed reductions of emissions are not germane to such a determination, as the words of the Act and its legislative history clearly indicate. Section 109(d) directs the Administrator to complete a review of all existing standards and criteria before the end of 1980 and at 5-year intervals thereafter and to revise them in whatever manner that review reveals is necessary. This promulgation is the result of such a review.

Assuring attainment and maintenance of ambient air quality standards is the responsibility of the States. Under section 110 of the Act, they are to submit to EPA for approval State Implementation Plans (SIPs) that provide for the necessary legal requirements for sources of the relevant pollutant so as to demonstrate attainment and maintenance of the standards by certain deadlines. In many areas of the country the ambient air quality standards are not being attained, despite the fact that the deadline for attainment has long since passed. As a remedy, Part D of the Act requires states with violations of ambient air quality standards to submit revised SIPs to ensure attainment of the standards and to meet certain new requirements of Part D by January 1, 1979. (Section 129(c), Pub. L. 95-95, note under 42 U.S.C. 7502.) The Act does not authorize the Administrator to extend that deadline, and consequently this revision of the photochemical oxidant standard does not affect the deadline for submittal of SIP revisions.

Section 110(a)(1) requires that SIP revisions be submitted within 9 months after a standard is revised. However, this provision refers to situations where a standard is tightened, with the result that existing SIPs are no longer adequate to attain and maintain the standard in question. Where a standard is relaxed, no SIP revision is required by the law, since states may have more stringent controls than necessary if they choose.

Furthermore, the change in the chemical species designation of the standard from photochemical oxidants to ozone does not make this standard subject to the provision of section 110(a)(1) cited above. The intent of the standard (total oxidant reduction), the control strategies, and the index of progress toward attainment (measured ozone levels) remain unchanged.

SUMMARY OF GENERAL FINDINGS FROM AIR QUALITY CRITERIA FOR OZONE AND PHOTOCHEMICAL OXIDANTS

On April 20, 1977, EPA announced (42 FR 20493) that it was reviewing and updating the 1970 criteria document for photochemical oxidants in accordance with provisions of section 109(d)(1) of the Clean Air Act as amended. The notice called for information and data that would be helpful in revising the document. In preparing the criteria document, EPA provided a number of opportunities for external review and comment. Two drafts of the document have been made available for external review, and EPA recieved more than 50 written comments on the first draft and approximately 20 on the second draft. The American Petroleum Institute has submitted extensive information that EPA considered in this standard review. The criteria document was the subject of two meetings of the Subcommittee on Scientific Criteria for Photochemical Oxidants of EPA's Science Advisory Board. Each of these meetings was open to the public, and a number of individuals presented both critical review and new information for EPA's consideration. A full discussion of comments received during the review process, as well as EPA's disposition of these comments, can be found in the docket (OAQPS 78-8) assembled for this rulemaking.

From EPA's review of the scientific information presented in the criteria document, several key areas with particular relevance to setting the ozone standard have emerged:

1. *Threshold concept*—Although the concept of an adverse health effect threshold has utility in setting ambient air quality standards, the adverse health effect threshold concentration cannot be identified with certainty. The lowest concentration which causes measured health effects in a scientific experiment depends on the particular subjects who have been studied because sensitivity to pollutants varies among different members of the population. Only limited studies can be performed on groups of unusually sensitive persons. Most experimental studies of human subjects are performed on small numbers of relatively healthy persons who do not fully reflect the range of human sensitivity. Also, the air to which the subjects are exposed does not include the full mix of chemicals other than the pollutant being studied which are in the ambient air. Some of these chemicals may be additive with the given pollutant in causing the adverse health effect, so that lower levels of the pollutant will result in the effect. Animal exposure studies cannot provide precise models of sensitive human populations. Thus, adverse health effect thresholds for sensitive persons are difficult or impossible to determine experimentally, while the threshold for healthy persons or animals is not likely to be predictive of the response of more sensitive groups. In this notice of rulemaking EPA uses the terminology "probable effects level" to refer to the level that in its best judgment is most likely to be the adverse health effect threshold concentration. It is the fact that the adverse health effect threshold concentration is actually unknown that necessitates the margin of safety required by the Act.

2. *Ozone health effects*—Ozone is a pulmonary irritant that affects the respiratory mucous membranes, other

lung tissues and respiratory functions. Clinical and epidemiological studies have demonstrated that ozone impairs the normal mechanical function of the human lung and causes clinical symptoms such as chest tightness, coughing and wheezing. These effects may occur in sensitive individuals, as well as in healthy exercising persons, at short-term ozone concentrations between 0.15 and 0.25 ppm. The clinical studies data base for these effects is far more extensive than that which was available in 1970, and these effects have now been demonstrated at lower levels than those cited in the 1970 criteria document.

3. *Effects on Asthmatics*—The best available evidence suggests that an elevated proportion of asthmatics experience attacks on days when the peak hourly oxidant concentrations reach about 0.25 ppm. This finding is based on a reevalution of the study by Schoettlin and Landau (1961).

4. *Toxicologic findings*—The key finding from toxicologic studies is the increased susceptibility to bacterial infection in laboratory animals exposed to 0.10 ppm ozone and a bacterial challenge. Infection rates are lower for animals exposed only to the bacterial challenge. Other effects such as biochemical changes, morphological abnormalities, and genetic changes have been found in some studies of animals exposed to ozone concentrations as low as 0.1 to 0.3 ppm. While the data from animal studies cannot be directly extrapolated to man, they can be taken as indicators of the full range of effects that may occur in humans. The epidemiology study by Durham (1974) that reported increased rates of illness in college students following periods of elevated air pollution levels (with peak oxidant being the pollution variable most strongly associated with illness) further increases our concern regarding the implications for man of the animal study findings.

5. *Ozone effects on aging processes*—A limited amount of data suggests that ozone may accelerate the aging process in living organisms. Exposure of rabbits to unspecified concentrations of ozone for 1 hour per week for a year has been reported to induce premature aging symptoms such as premature cartilage calcification, severe depletion of body fat, and the general signs of aging (Stokinger, 1965).

6. *Pollutant interactions*—The fact that ozone exposure is frequently accompanied by exposure to other pollutants, such as sulfur dioxide (SO_2), has prompted several investigators to conduct laboratory evaluations of exposure of human subjects to combinations of O_3 and other pollutants. Simultaneous exposures to 0.37 ppm O_3 and 0.37 ppm SO_2 were reported to produce larger changes in pulmonary function than exposure to either pollutant alone. No obvious effects were observed in other simultaneous exposure tests using 0.25 ppm O_3 and 0.3 ppm nitrogen dioxide (NO_2), as well as O_3; NO_2, and 30 ppm carbon monoxide (CO). Nevertheless, the SO_2-O_3 synergism findings support the need for an adequate margin of safety in the ozone standard.

7. *Mortality studies*—No studies have conclusively linked exposure to ozone or photochemical oxidants with an increase in human mortality. A number of epidemiologic studies have been designed and conducted to demonstrate this effect, but in each case the results have been negative or inconclusive.

8. *Welfare effects*—Ozone accelerates the aging of many materials, resulting in rubber cracking, dye fading and paint erosion. These effects are linearly related to the total dose of ozone and can occur at very low levels, given long-duration exposures. Damage to vegetation, as expressed by decreased growth and yield, is related to the long-term (growing season) mean of the daily maximum 6- to 8-hour-average ozone concentrations.

9. *Causes and control of oxidant pollution*—All presently available evidence indicates that around urban centers with severe oxidant problems, the major concern is the formation of photochemical oxidants from man-made organic and nitrogen oxide emissions. Control of these emissions will result in significant reductions in ambient ozone, peroxyacetylnitrate (PAN), aldehydes and photchemical aerosol.

As is the case with most standard-setting activities, the data base on ozone will continue to expand after the standard is set. EPA will continue to inform itself of new research results and also will accelerate the schedule for its own research on the health effects of ozone and other photochemical oxidants at low exposure levels. The Agency plans to make the results of these studies available as they are completed and to issue an interim report on all new research results in two years.

RULEMAKING PETITIONS

The Agency was petitioned by the American Petroleum Institute (API) and 29 member companies on December 9, 1976, and by the City of Houston on July 11, 1977, to revise the criteria, standards and control strategy guidelines for photochemical oxidants. EPA had already begun such a revision when both petitions were filed, and the Agency responded that it was deferring decision on these petitions until the rulemaking was completed. EPA considers this final rulemaking and the accompanying one on control strategy guidelines to be the Agency's final action on these petitions. A summary of the two petitions and EPA's response is given below.

The API petition requested that EPA revise the air quality criteria document for photochemical oxidants in light of new information regarding the causes, effects, and extent of air pollution attributed to ozone and other oxidants. EPA has published a revised air quality criteria document for photochemical oxidants; in the Agency's judgment, this document accurately reflects the latest scientific information regarding the causes, effects, and extent of air pollution attributed to ozone and other oxidants.

The second request in the API petition was that EPA establish a national primary ambient air quality standard based on new studies that allegedly demonstrate no significant adverse human health effects at or below ozone levels of 0.25 ppm for 2-hour exposures. As requested by API and as required under the Clean Air Act, the Agency has considered all new studies published since 1971 that are relevant to setting a revised primary standard the attainment and maintenance of which would, in the Administrator's judgment, protect the public health with an adequate margin of safety. EPA disagrees with API's conclusion that new studies conducted since 1971 demonstrate no significant adverse human-health effects at or below 0.25 ppm.

A more detailed discussion of EPA's judgments regarding reported or probable health consequences at concentrations below 0.25 ppm is presented in the rationale for revising the primary standard and in the response to comments, which appear elsewhere in this notice.

The third request by API was that the national secondary ambient air quality standard be based on adverse effects on public welfare as indicated by studies using ozone-specific measurement methods. In addition, API concluded that Congress intended that EPA weigh the overall economic and social impact of a lower secondary standard against adverse effects of a pollutant. EPA has reviewed the data presented in the criteria document and concluded that there is currently no evidence of a significant decrease in yield or growth to commercially important crops for short-term exposures to ozone concentrations below 0.12 ppm. EPA believes a secondary standard more stringent than the primary standard is unnecessary and that a cost-benefit analysis is not required.

In their petitions, both API and Houston requested EPA to state the primary and secondary standards so as to permit reliable assessments of compliance. EPA agrees that the present deterministic form of the oxidant standard has several limitations and has made reliable assessment of compliance difficult. The revised ozone air quality standards are stated in a statistical form that will more accurately reflect the air quality problems in various regions of the country and allow more reliable assessment of compliance with the standards.

The API and Houston petitions requested that EPA specify the use of an appropriate measurement method for monitoring ambient concentrations of ozone. API suggested the use of ethylene chemiluminescence calibrated by either gas phase titration (GPT) or ultraviolet (UV) photometry. As a result of EPA's continuing evaluation of several calibration techniques, the Agency has defined the reference method to be ethylene chemiluminescence calibrated by UV photometry. (See the amendment to Appendix D of 40 CFR Part 50 elsewhere in this edition of the FEDERAL REGISTER.) EPA is allowing the use of a modified version of the current calibration method (acidified KI) as an interim measure to avoid problems that would result from immediate conversion to UV photometry.

Both the API and Houston petitions requested revision of the State Implementation Plan (SIP) requirements (1) to delete the assumption of no background concentration of photochemical oxidants and (2) to specify more reliable, alternative oxidant prediction relationships to replace Appendix J of 40 CFR Part 51 for determining the degree of necessary precursor emission reductions.

With respect to the first point, EPA recognizes that background concentrations and transport of ozone from upwind locations can contribute to high levels of ozone in or near an urban area during the afternoon hours. Therefore, several revisions are being made in control strategy and implementation guidelines for ozone. The revised guidelines set forth procedures for consideration of both upwind transport and irreducible natural background by the States in calculating the necessary reductions in hydrocarbon emissions. In response to the second request, EPA has determined that Appendix J of 40 CFR Part 51 no longer represents an acceptable analytical relationship between hydrocarbons and ozone. Appendix J is, therefore, being deleted. EPA will now allow States to use any of four analytical techniques to determine the amount of hydrocarbon reduction necessary to demonstrate attainment of the national ozone air quality standards: (1) Photochemical dispersion models, (2) Empirical Kinetics Modeling Approach (EKMA), (3) Empirical and statistical models, and (4) Proportional rollback. These four techniques are discussed further in the revision of Part 51, which appears elsewhere in this edition of the FEDERAL REGISTER.

The Houston petition requested that EPA consider information in their petition relative to atmospheric conditions and other factors that affect photochemical oxidants in the Houston area. The petition claimed that the air pollution problems in Houston warrant special attention in standard-setting and "tailor-made" control strategies, because the emission and meteorology situations and the overall pollution picture in that area are "unique."

In response to the above claim, it should be noted that the majority of the data presented in the revised criteria document are based on ozone exposure. Nearly all of the clinical and toxicological studies are based on the effects of ozone. The biomedical data also suggest that many of the effects observed during periods of elevated photochemical oxidant concentrations are reasonably attributable primarily to ozone in the ambient air. Since the primary and secondary standards are based on the effects of ozone, the differences between areas in their overall photochemical oxidant mixtures do not bear upon the setting of national ozone air quality standards.

EPA agrees with the Houston petition that components of the photochemical oxidant mixture other than ozone may have an adverse impact on health and/or welfare. The data base is not, however, sufficient at this time to justify a separate standard for PAN or other non-ozone oxidants. While EPA does not propose to establish separate standards for the non-ozone constituents of the mixture at this time, those measures taken to reduce ozone precursor emissions will also reduce PAN and other non-ozone oxidant concentration levels.

In response to Houston's request for a unique standard based on their local situation, it must be realized that the Clean Air Act does not contemplate separate standards for different cities. Dealing in terms of *national* ambient air quality standards, the Act charges EPA to identify the air quality levels which must be attained and maintained to ensure, with an adequate margin of safety, that adverse health effects will not occur.

The Houston petition also requested that EPA include realistic requirements for the reduction of oxides of nitrogen as conditions in the Houston area may indicate to be necessary to achieve the revised standards. EPA's response is that it is the responsibility of the State of Texas and the City of Houston to submit State Implementation Plan provisions tailored to the situation prevailing in Houston. If the current SIP is not representative of the most efficient means of reducing ozone in Houston, then, with Houston's assistance, Texas should submit a revision that is consistent with local emission and meteorological conditions.

SUMMARY OF COMMENTS RECEIVED

EPA has solicited public comment and critique on proposed revisions to the photochemical oxidant air quality standard during all phases of the standard development process. Prior to proposal (April 20, 1977), EPA announced (42 FR 20493) that it was reviewing and updating the criteria document and called for information that might be helpful in revising the document. Public comments were received on two drafts of the criteria document, and the public was invited to two meetings of the Subcommittee on Scientific Criteria for Photochemical Oxidants of EPA's Science Advisory Board. In addition, the Agency held a public meeting on January 30, 1978, to receive comments from interested parties prior to development of any formal Agency position on the initial proposed revision of the standard. In particular, EPA actively solicited the participation of the State and Territorial Air Pollution Program Administrators (STAPPA) and the Association of Local Air Pollution Control Officials (ALAPCO) in this meeting; several representatives of these groups offered comments at the meeting. The results of this meeting are discussed in the proposed regulation (43 FR 26970) and a transcript of the meeting is available in docket OAQPS 78-8.

Following proposal, EPA held four public meetings to receive comments on the proposed standard revisions. Meetings were held in Washington, D.C.—July 18; Atlanta, Ga.—August 17; Dallas, Tex.—August 22; and Los Angeles, Calif.—August 24; transcripts are available in docket OAQPS 78-8. In addition, 168 written comments were received during the formal comment period, which extended through October 16, 1978.

The principal comments and Agency responses are summarized in the following paragraphs (individual responses to comments are contained in docket OAQPS 78-8). EPA also received comments on the proposed standard after October 16. Although EPA does not have a legal obligation to review these comments, all significant issues raised in the post-October 16 comments have been addressed and responded to as part of the discussion of comments in this preamble. As with all other documents considered or examined by EPA as part of its decision process, these documents have been placed in the public docket and have become part of the administrative record of this decision.

The majority of comments received (132 out of 168) opposed EPA's proposed standard revision, favoring either a more relaxed or a more stringent standard. State air pollution control agencies (and STAPPA) generally supported a standard level of 0.12 ppm on the basis of their assessment of an adequate margin of safety. Municipal groups generally supported a standard level of 0.12 ppm or higher, whereas most industrial groups supported a standard level of 0.15 ppm or higher. Environmental groups generally encouraged EPA to retain the 0.08 ppm standard.

Comments on the proposed revisions were received from five Federal agencies. Three of the agencies endorsed the proposed primary standard, but one of these agencies requested that EPA consider formulating the standard on a daily maximum hourly average basis. Another agency expressed concern that EPA had inadequately substantiated the rationale for raising the primary standard level and requested that the final revisions provide further analysis in this regard. Finally, the Executive Office of the President/Council on Wage and Price Stability suggested, through the Regulatory Analysis Review Group, that the proposed standard was unnecessarily stringent, recommending that EPA set the primary standard using an alternative methodology that focuses on the marginal costs per person-hour of ozone effects avoided.

Groups and individuals submitting comments are identified below:

COMMENTS RECEIVED ENDORSING CURRENT PRIMARY STANDARD LEVEL OF 0.08 PPM

ORGANIZATION AND AGENCIES

American Lung Association of Colorado
American Lung Association of Colorado, West Region
American Lung Association of Louisiana
American Lung Association of New Jersey
American Lung Association of New York State, Inc.
Bangor-Brewer TB and Health Association, Maine
California Lung Association
Connecticut State Department of Health
Environmental Confederation of Southwest Florida
Environmental Defense Fund
Ms. Nancy C. Fahden, Supervisor District Two, Contra Costa County (Calif.) Board of Supervisors
Florida Lung Association
Greenleaf Nurseries, Warsaw, Indiana
Issac Walton League, Manasota Chapter
League of Women Voters of the U.S.
League of Women Voters of Dallas, Texas
Maine Health Systems Agency
Maine Lung Association
Medford-Ashland Air Quality Maintenance Advisory Committee, Oregon
Michigan Lung Association
Michigan Lung Association, Saginaw Valley Region
National Air Conservation Commission, American Lung Association
Natural Resources Advisory Committee, Cedar Grove, N.J.
Natural Resources Defense Council
New Mexico Lung Association
Oregon Environmental Council
Oregon Lung Association
Queensboro Lung Association, Jamaica, N.Y.
Sierra Club
Sierra Club, Houston Chapter
South Shore (Ohio) Christmas Seal Association
Southwestern Ohio Lung Association
U.S. Department of the Interior
Washington Air Quality Coalition
Yale Environmental Law Association

Summary. 35 comments from organizations, agencies or their representatives and 38 comments from concerned citizens supporting the current primary standard level of 0.08 ppm.

COMMENTS RECEIVED ENDORSING PROPOSED PRIMARY STANDARD LEVEL OF 0.10 PPM

ORGANIZATIONS AND AGENCIES

Air Pollution Control League of Greater Cincinnati
Air Quality Advisory Committee, California Department of Health
California Air Resources Board
Coalition of Labor and Business (COLAB), Concord, California
Colorado Department of Health
Connecticut Department of Environmental Protection
Massachusetts Department of Environmental Quality Engineering
Public Health Service, U.S. Department of HEW
Regional Planning Commission for Jefferson, Orleans, St. Bernard and St. Tammany Parishes, Louisiana
Rhode Island Lung Association
Southern Alameda County Board of Realtors, California
U.S. Department of Energy
U.S. Department of Transportation
Wasatch Front Regional Council, Utah
Wayne County Department of Health, Michigan
Wisconsin State Department of Natural Resources

Summary. 16 comments from organizations, agencies or their representatives and 1 comment from a concerned citizen endorsing the proposed primary standard level of 0.10 ppm.

COMMENTS RECEIVED ENDORSING A PRIMARY STANDARD LEVEL OF 0.12 PPM

STATE AND LOCAL AGENCIES

Alabama Air Pollution Control Commission
Berkeley, Charleston, and Dorchester (S.C.) Council of Governments
City of Philadelphia, Pennsylvania
Georgia Department of Natural Resources
Indiana State Board of Health
Kansas Department of Health and Environment
Kentucky Department for Natural Resources and Environmental Protection
Maryland Environmental Health Administration
Michigan Department of Natural Resources
Nebraska Department of Environmental Control
Nevada Department of Conservation and Natural Resources
New York Department of Environmental Conservation
North Carolina Department of Natural Resources and Community Development
Pennsylvania Department of Environmental Resources
Tennessee Department of Public Health
Utah Bureau of Air Quality
Virginia Air Pollution Control Board

ORGANIZATIONS AND COMPANIES

Area Cooperation Committee of Tidewater and Virginia Peninsula Chambers of Commerce
Evansville, Indiana, Chamber of Commerce
Sierra Pacific Power Company
State and Territorial Air Pollution Program Administrators
Texas Oil Marketers Association
Vulcan Materials Company, Wichita, Kansas

Summary. 17 comments from State and local agencies and 6 comments from organizations and corporations supporting a primary standard level of 0.12 ppm.

COMMENTS RECEIVED ENDORSING A PRIMARY STANDARD LEVEL HIGHER THAN 0.12 PPM AND/OR CONTENDING PROPOSED STANDARD TOO STRINGENT

	Endorse standard higher than 0.12 ppm	Proposed standard too stringent
Organization or agency:		
American Petroleum Institute (API)	X	X
Association of Local Air Pollution Control Officials		X
Associated Building Industry of Northern California		X
Cook County Dept. of Environmental Control, Illinois		X
Dow Chemical Company	X	
Eastman Kodak Company	X	
General Motors Corporation	X	X
Great Plains Legal Foundation		X
Greater San Antonio Chamber of Commerce, Texas		X
Houston Chamber of Commerce, Texas		X
Iowa-Illinois Gas and Electric Company		X
Louisiana Air Control Commission	X	
Manufacturing Chemists Association		X
Monsanto Chemical Intermediates Co	X	X
Motor Vehicle Manufacturers Association	X	X
National Flexible Packaging Association	X	X
New Orleans Public Service, Inc	X	
Oklahoma State Dept. of Health		X

COMMENTS RECEIVED ENDORSING A PRIMARY STANDARD LEVEL HIGHER THAN 0.12 PPM AND/OR CONTENDING PROPOSED STANDARD TOO STRINGENT—Continued

	Endorse standard higher than 0.12 ppm	Proposed standard too stringent
Owens-Illinois	X	X
Rio Blanco Oil Shale Company	X	
St. Louis County, Missouri	X	
San Antonio Metropolitan Health District, Texas	X	
Shell Oil Company		X
Stearns-Roger, Inc., Denver, Colorado		X
Tennessee Eastmen Corp.		X
Texas Air Control Board	X	
Texas Chemical Council	X	
U.S. Council on Wage and Price Stability		X
Utah Manufacturers Association		X
Virginia Air Pollution Control Board		X
Western Oil and Gas Association		X
White River Shale Project		X

Summary: 15 comments from organizations, agencies, and companies and 4 comments from concerned citizens supporting a primary standard level higher than 0.12 ppm. 23 comments stating the proposed standard is too stringent.

The principal issues raised during the comment period relate to the following topics:

I. Health effect criteria and selection of the primary standard.

A. Definition of an Adverse Health Effect.

B. EPA's interpretation of cited studies.

C. Margin of safety.

D. Use of animal studies.

E. Exposure of sensitive groups.

F. Synergistic effects and chemical species designation of the standard.

II. Risk assessment method.

III. Welfare effects and the secondary standard.

IV. Implementation and attainability.

A. Value of hydrocarbon control and timing of SIP submissions.

B. Consideration of control costs.

C. Natural background concentrations.

V. Procedural issues.

The comments received have been reviewed and a document detailing their disposition has been placed in the rulemaking docket (OAQPS 78-8) for public inspection. The following sections summarize the significant comments and present the Agency's responses.

I. HEALTH EFFECT CRITERIA AND SELECTION OF THE PRIMARY STANDARD

A. DEFINITION OF AN ADVERSE HEALTH EFFECT

Comment. The proposed standard is unsuitable because EPA has never defined what constitutes "protection of public health." As a specific example, EPA has not shown that pulmonary function and ventilatory pattern changes are adverse health effects.

Agency Response. As stated in the criteria document, the available evidence regarding pulmonary function changes observed in clinical exposures of healthy subjects to ozone does not suggest that small changes in lung function (unaccompanied by discomfort symptoms or impairment of oxygen uptake) would interfere with normal activity in healthy individuals. However, even small changes in people with underlying respiratory disease such as asthma, chronic bronchitis, and emphysema can interfere with normal activity and, thus, may signal impairment of public health.

Comment. EPA should identify where adverse effects begin in the continuum of responses to pollutants.

Agency Response. In conducting a preliminary risk assessment, EPA interviewed several biomedical experts to obtain their judgments as to the risk of exceeding the threshold of adverse health effects in sensitive persons for alternative standard levels. An essential feature of this risk assessment procedure is the utilization of the experts' judgments as to the point in the continuum of physiological responses to ozone that must be exceeded for an adverse health effect to occur. As an example, discussions with several experts indicated that a 1 percent decrease in pulmonary function (e.g., forced expiratory volume 1-second test) would be inconsequential, whereas a 50 percent decrease would be a severe effect in sensitive persons; the experts' judgments varied as to the point at which adverse effects would begin, but fell within the range of a 5 to 15 percent decrease.

Comment. Quickly reversible irritation experienced for a short period of time is a welfare effect related to personal comfort and well-being and should therefore be considered in connection with the secondary standard.

Agency Response. The criteria document states that physical discomfort, as manifested by symptoms such as difficulty in breathing, chest tightness, and pain on deep inspiration, has usually been observed in clinical studies in conjunction with pulmonary function changes. Even when reversible, respiratory symptoms may restrict normal activity or limit the performance of tasks. In clinical studies, exposure of *healthy subjects* to realistic levels of ozone (0.3 ppm) has produced discomfort sufficient to prevent completion of experimental protocols, particularly when vigorous exercise was involved. Accordingly the criteria document concluded that increased rates of respiratory symptoms constitute impairment of public health. On this topic, a physician affiliated with the California Department of Health stated (docket OAQPS 78-8, IV-F-31) that it was his medical opinion that symptoms such as those described above constitute adverse health effects, inasmuch as they signal pulmonary function decrements and an increased pulmonary work load for affected individuals. He expressed his concern for the long-term effect of repeated exposure to levels of ozone sufficient to induce such symptoms. EPA concurs in this view and considers such symptoms, even though transitory, to be of concern in selecting the level of the primary standard.

B. EPA'S INTERPRETATION OF CITED STUDIES

1. *DeLucia and Adams (1977)*

Comments. (a) EPA misread the DeLucia and Adams study in claiming significant effects have been reported at 0.15 ppm for one hour.

(b) Mouthpiece breathing may have invalidated the DeLucia and Adams study.

(c) Since DeLucia and Adams demonstrated effects at 0.15 ppm in healthy individuals, more susceptible populations would be expected to sustain effects at lower levels.

Agency Responses. (a) EPA acknowledges that DeLucia and Adams failed to demonstrate any statistically significant decrements in pulmonary function resulting from exposure to 0.15 ppm for one hour. (The investigators did observe statistically significant decrements in pulmonary function resulting from exposure to 0.30 ppm for one hour.) In groups as small as those tested by DeLucia and Adams (six subjects), however, tests of statistical significance are difficult to interpret. The criteria document concluded that the study by DeLucia and Adams, although unreplicated, has raised the question of whether O_3 concentrations as low as 0.15 ppm exert effects in a portion of healthy subjects exercising vigorously. Indeed, DeLucia and Adams specifically state that the two most sensitive subjects sustained markedly impaired respiratory function and exercise ventilatory patterns during the two most stressful exercise protocols in the four ozone-exposure experiments (i.e., both 0.15 ppm and 0.30 ppm).

Furthermore, DeLucia and Adams state that most of the subjects experienced subjective symptoms of discomfort (e.g., congestion, chest pain, and cough) when exposed to 0.15 ppm for one hour under the most stressful exercise protocol (equivalent to running about 6 miles in an hour). These symptoms occurred at a lower excercise rate when the subjects were exposed to 0.30 ppm. DeLucia and Adams did not report the incidence of these symptoms in a quantitative manner, but this fact does not remove EPA's concern about the implications for healthy persons such as those studied by DeLucia and Adams, or for more susceptible persons who may sustain more severe reactions or who may be affected at lower concentrations than those observed.

(b) As noted in the criteria document, persons tend to breathe through their mouths when exercising. Thus, DeLucia and Adams' utilization of mouthpieces to dispense O_3 probably represents actual exposures in persons who, in the course of their normal daily activities, are undergoing exercise.

(c) EPA agrees with this comment, as noted above. EPA considered the implications of this study for more susceptible members of the population in its determination of the margin of safety for the ozone standard.

2. *Schoettlin and Landau (1961)*

Comments. (a) There are still problems with reliance on this study because (1) ambiguities remain in its interpretation and (2) more recent studies of effects of ozone on asthmatics have failed to corroborate this study's conclusions.

(b) EPA's interpretation of the concentration at which Schoettlin and Landau correlated increased incidence of asthmatic attacks is unnecessarily conservative. There is good reason to believe that the 0.25-ppm oxidant concentration cited by Schoettlin and Landau was a daily peak (2-minute average) concentration rather than a daily maximum hourly average concentration, as EPA claims. Furthermore, the level of ozone occurring on these high oxidant days would have been less than the level of oxidant reported.

Agency Responses. (a) The criteria document recognizes limitations that make it difficult to interpret the Schoettlin and Landau study unequivocally. Nevertheless, Schoettlin and Landau did conclude that the proportion of asthmatics having attacks was significantly greater on days when the oxidant concentration exceeded 0.25 ppm than on days when the concentration was below that level. EPA does not believe that this conclusion has been refuted by more recent studies. The reported results of the recent epidemiological study by Kurata et al (1976) are qualitatively similar to those of Schoettlin and Landau. EPA's analysis (docket OAQPS 78-8, IV-A-1) of the data presented in the Kurata study indicates that a statistically significant elevation of the asthma index occurred on days when the maximum instantaneous (2-minute average) oxidant concentrations exceeded 0.28 ppm. While the exact hourly average equivalent of this value is not known, it must be less than or equal to 0.28 ppm, and is probably in the range of 0.20 to 0.27 ppm.

(b) EPA acknowledges that it is uncertain from Schoettlin and Landau's paper what averaging time was used in correlating oxidant concentration and incidence of asthma attacks. As stated in the criteria document, however, consultations with the authors have established that daily asthma attack rates were correlated with daily *maximum hourly average* oxidant levels. EPA considers that these consultations (docket OAQPS 78-8, IIA-C-2) have satisfactorily resolved the controversy regarding the averaging times used by Schoettlin and Landau.

EPA agrees with the comment that ozone levels may have been lower than the oxidant readings with which Schoettlin and Landau correlated asthma attack incidence. Ozone levels have been shown to range from approximatley 65 percent to nearly 100 percent of the total oxidant levels. This fact provides reason for concern that ozone in the ambient air at daily maximum hourly average concentrations less than 0.25 ppm may adversely affect asthmatic persons.

3. *Hammer et al. (1974)*

Comments. (a) This study has methodological problems (such as the failure to adjust the data for smoking habits and allergy histories) that undermine confidence in its conclusions.

(b) It is uncertain that oxidants caused the increase in symptoms observed in this study.

Agency Responses. (a) Hammer et al. conducted a longitudinal survey of an essentially constant group of subjects over a period of time. Consequently, in order for the authors' failure to adjust the data for smoking habits and allergy histories to have biased the results, the survey reponse pattern on high pollution days would had to have differed with respect to the distribution of smokers and allergic persons as compared with the pattern on low pollution days. Such an occurrence seems unlikely; furthermore, the criteria document noted that the results of this epidemiological study are generally consistent with the results of clinical exposure studies. This fact, along with the extensive data base evaluated (about 53,000 person-days of observation), enhances the reliability of Hammer's study.

(b) Hammer et al. found that symptom frequencies were more closely correlated to photochemical oxidants than to several other environmental parameters (e.g., carbon monoxide and nitrogen dioxide). In addition, the criteria document noted that the oxidant levels at which cough and chest discomfort were observed to increase in the student nurse population were quite similar to ozone concentrations that have been observed to produce impairment of pulmonary function and respiratory irritation in experimental exposures of healthy subjects performing intermittent light exercise (0.37 ppm for 2 hours). Consequently, it is reasonable to propose that photochemical oxidants—and specifically ozone in the ambient air—contributed substantially to observed increases in rates of cough, chest discomfort, and headache.

4. *Hazucha (1973)*

Comment. Results reported by Hazucha on impairment of pulmonary function at ozone levels of 0.25 ppm for 2 hours are not statistically significant.

Agency Response. The small number of subjects (three) examined at that exposure precludes the application of statistical methods to the results. The absolute value of the pulmonary function decrements (about 5 percent) is the more relevant factor in evaluating the results of this study.

As described in the criteria document, the small pulmonary function changes observed by Hazucha in a 2-hour exposure of healthy subjects undergoing intermittent light exercise lie along a continuum of responses when compared with results at higher concentrations and similar exposure regimes. There is no indication that 0.25 ppm is the threshold for that exercize level, and indeed the study by DeLucia and Adams (1977) has shown symptomatic effects in *healthy* individuals that are indicative of pulmonary function impairment at levels as low as 0.15 ppm under a more strenuous exercise protocol.

5. *Studies in which effects were not observed at levels above 0.15 ppm*

Comments. (a) The 1977 National Academy of Sciences (NAS) document, Ozone and Other Photochemical Oxidants, was cited in several comments as concluding that effects in human subjects have been observed only from ozone exposures above 0.25 ppm.

(b) Linn et al. (1978) failed to find any significant pulmonary effects in asthmatics exposed to 0.20-0.25 ppm for 2 hours under conditions of heat and exercise.

(c) Hackney et al. (1975) observed human health effects only at exposures above 0.25 ppm for 2 hours.

Agency Responses. (a) The NAS document states that "some limited studies show evidence of human health effects of exposure to pure ozone at concentrations as low as 0.25 ppm * * *" This document was prepared before publication of the DeLucia and Adams study, which suggests effects at lower levels. Furthermore, this NAS document in no way concludes that effects resulting from ozone, as it occurs in the ambient photochemical mix, do not occur at concentrations below 0.25 ppm.

(b) Although Linn et al. found statistically significant changes in one of several measures of pulmonary function in their laboratory study, the manner in which the investigators conducted the study (e.g., persons with marked respiratory disability were excluded from the study) and analyzed the data are such that the observed results probably underestimate the effects that would occur at similar ambient exposure levels. There was a slight increase in symptom scores during ozone exposure, and statistically significant changes in blood biochemical factors were observed. While the clinical significance of these latter changes is uncertain, they do represent alterations in normal body functions and cannot be discarded in selecting a standard that protects public health with an adequate margin of safety.

(c) Although the criteria document states that Hackney et al. observed no lung function changes of note at 0.25 ppm for 2 hours even among "reactive" subjects (persons giving a history of cough, chest discomfort, or wheezing in response to allergy or air pollution exposure), closer inspection of the Hackney et al. (1975) studies reveals that dose-response relationships hold for sensitive subjects for lung function and blood biochemical effects across the range of exposure from 0.20 to 0.50 ppm ozone.

6. *Other Human Studies*

Comments. (a) Von Nieding et al. (1976) have demonstrated effects on pulmonary function of healthy individuals at 0.10 ppm ozone.

(b) EPA cannot justify a conclusion that Japanese epidemiological studies indicate a risk of symptomatic effects in human beings from ozone exposures below 0.15 ppm for one hour.

Agency Responses. (a) EPA is concerned about the findings of von Nieding et al. showing decreased oxygen pressure in arterialized blood and increased airway resistance after 2 hours of exposure to 0.10 ppm ozone and intermittent light exercise. The criteria document points out, however, that the investigators used non-standard physiologic measurement methods. Thus, although von Nieding's findings cannot be ignored in the standard-setting process, they are unconfirmed, and must be interpreted cautiously.

(b) Makino and Mizoguchi (1975) reported an epidemiological study of Tokyo students that showed increased rates of discomfort symptoms on days when the oxidant level (believed to be a daily maximum hourly average concentration) exceeded 0.15 ppm as compared with days when it fell below 0.10 ppm. The criteria document reviewed this and several other Japanese epidemiological studies, and concluded that the studies were appropriately designed but that it is very difficult to interpret their results. In setting a standard with an adequate margin of safety, however, EPA must consider evidence such as these Japanese studies and must evaluate the uncertainties which medical research has not yet resolved.

7. *Validity of Clinical Studies in General*

Comment. At the August 22, 1978 public hearing in Dallas, testimony was presented alleging that the ozone generators used in clinical health studies produce other toxic materials in addition to ozone. Experimental data obtained using a new total oxidant monitoring method indicated that these additional oxidants were present in large quantities (as high as 300 percent greater than ozone). It was hypothesized that the adverse effects noted in clinical studies may be preponderantly caused by the additional oxidants and not ozone.

Agency Response. EPA has concluded that the experimental evidence offered to support these findings is unconvincing and cannot be substantiated. The results of an experimental program initiated by EPA after the Dallas hearing indicate that the new monitoring technique which supposedly measured ozone and any additional oxidants has a variable chemical reaction relationship (stoichiometry) with ozone depending on whether or not oxygen is present. The higher oxidant readings obtained by this technique appear to result from this variable stoichiometry rather than representing the presence of any additional non-ozone oxidants. Furthermore, an exhaustive search for such oxidants in the output of ozone generators operating under various conditions (using as the input stream either dry or humidified tank air or oxygen, with very low or background concentrations of hydrocarbons, mostly methane) failed to produce any evidence of non-ozone oxidants. Consequently, EPA judges the hypothesis offered by this comment to be experimentally unsupportable. A report documenting the results of EPA's experimental program has been placed in the docket (OAQPS 78-8, IV-A-2).

C. MARGIN OF SAFETY

Comment. EPA has proposed a standard with an inappropriate margin of safety. The margin of safety was criticized as being either inadequate or too great.

Agency Response. The Clean Air Act requires that EPA set air quality standards that are requisite to protect the public health, allowing an adequate margin of safety. As stated in the legislative history of the Clean Air Act, the standard must protect against hazards that research has not yet identified. EPA feels that the decision regarding an adequate margin of safety is a *judgment* which must be made by the Administrator after weighing *all* the medical evidence bearing on ozone. The factors to be taken into account include inconclusive evidence as well as findings from studies that are considered definitive and not subject to challenge. For example, in selecting an adequate margin of safety, the Administrator must consider: (1) findings from animal studies that show increased susceptibility to infectious respiratory disease and other serious effects at relatively low ozone levels, (2) the concern that health studies may not always reflect the health impact in more sensitive segments of the population, and (3) studies suggesting that ozone may produce an enhanced effect when combined with other air pollutants commonly present in the urban atmosphere but not present in clinical study chambers.

D. USE OF ANIMAL STUDIES

Comment. EPA has failed to give appropriate consideration to the results of animal studies, especially those involving young animals and those examining reduced resistance to infection.

Agency Response. EPA is concerned about the studies which have demonstrated effects in young animals and decreased resistance to infection in animals exposed to ozone. The infection effect has been demonstrated at exposures as low as 0.08 ppm for 3 hours. The criteria document concluded that these findings have definite human health implications, although different exposure levels may be associated with such effects in humans. For this reason, these results cannot be the sole factor used in selecting the level of the primary standard. However, as is the case with other inconclusive evidence, EPA must consider these studies in selecting an adequate margin of safety.

Comment. There is no evidence of reduced resistance to infection in epidemiologic studies in places such as Los Angeles.

Agency Response. Epidemiological studies have been inconclusive in demonstrating this effect in man. However, EPA does not agree with this comment. The study by Durham (1974) of air pollution effects on college students, indicates that rates of new illness increase following short-term exposures to elevated pollutant concentrations. The pollutant variable most strongly associated with illness was peak oxidant. Also, several studies documenting increased levels of mucous membrane irritation during periods of ozone exposure suggest indirectly that susceptibility to infection may rise during these periods. Furthermore, although animal study findings cannot be directly extrapolated to man, the criteria document concludes that the reactions observed in mice represent effects on basic biological responses to infectious agents, and there is no reason to believe that the pollutant-induced alterations of basic defense mechanisms that occur in mice could not occur in human beings. Thus, these studies cannot be ignored in the standard-setting process.

E. EXPOSURE OF SENSITIVE GROUPS

Comment. EPA is being unnecessarily stringent in selecting the sensitive population. The standard could be much less stringent without endangering the health of such persons if EPA accounted for the portion of time that persons are indoors and, thus, not exposed to higher ambient concentrations.

Agency Response. The legislative history of the Clean Air Act makes quite clear Congress' intention to protect sensitive persons (asthmatics and emphysematous patients are cited as examples) who in the normal course of daily activity are exposed to the ambient environment. Air quality standards are to be established with reference to protecting the health of a representative sample of persons comprising the sensitive group rather than a single person in such a group. Standards must be based on a judgment of a safe air quality level and not on an estimate of how many persons will intersect given concentration levels. EPA interprets the Clean Air Act as providing citizens the opportunity to pursue their normal activities in a healthy environment.

F. SYNERGISTIC EFFECTS AND CHEMICAL SPECIES DESIGNATION OF STANDARD

Comment. There were objections to the proposed change of the chemical designation of the standard from photochemical oxidants to ozone because the health impacts of photochemical air pollution arise not only from ozone, but also from the spectrum of other gaseous and particulate pollutants that co-exist with ozone. There was also concern that the change in the chemical designation signalled a change in emphasis in oxidant control efforts that would impede progress in the reduction of non-ozone components of the photochemical oxidant mixture such as peroxyacetylnitrate (PAN). Specific concern was expressed regarding the eye-irritating components of the mixture, since at ambient levels ozone alone is not an eye irritant.

Agency Response. Certain clinical studies (such as Hazucha and Bates, 1975) have demonstrated the potential for greater health impacts resulting from exposure to ozone in combination with other pollutants which occur in the ambient air than from exposure to ozone alone. The ozone standard is not intended merely to protect against the levels of ozone that have been demonstrated to produce effects in clinical studies where subjects have been exposed to highly purified air to which ozone alone has been added. Rather, setting an ozone standard with an adequate margin of safety involves, among other considerations, evaluating the effects of ozone as it occurs in the ambient air, in combination with other pollutants.

One reason for changing the chemical designation of the standard from photochemical oxidants to ozone is to correct an inconsistency between the title of the standard (photochemical oxidants) and the chemical species (ozone) that has always been measured by the reference method used to estimate ambient oxidant levels and determine compliance with the standard. Consequently, no redirection of control efforts is contemplated; i.e., reductions in hydrocarbon and nitrogen oxide emissions will continue to be required in order to reduce the levels of the secondarily generated pollutant (ozone) measured to determine compliance with the standard.

The criteria document examined the issue of whether or not measures taken to reduce ozone will also reduce other manifestations of photochemical pollution such as eye irritation. The evidence from laboratory and theoretical studies indicates that, for urban atmospheres, reductions in hydrocarbon and nitrogen oxide emissions should have even greater impacts on ambient PAN than on ambient ozone. Similarly, laboratory data suggest a linear relation between hydrocarbon emissions and ambient levels of photochemically produced aldehydes. Since PAN and such aldehydes as fomaldehyde and acrolein are know to be eye irritants, the criteria document concludes that emission control measures for ozone reduction will probably have a positive effect on reducing eye irritation in those situations where eye irritation is associated with photochemical processes (e.g., Los Angeles).

II. RISK ASSESSMENT METHOD

Comment. The risk assessment method should not be used at this time because it has not been reviewed adequately by the Science Advisory Board or the scientific community.

Agency Response. The risk assessment method is not being used to set the ozone standard. In determining what ozone standard has an adequate margin of safety, however, the findings of the initial application of the risk assessment method to ozone have been considered. EPA agrees that the method has not received sufficient review. The method will be published in the open literature and the Science Advisory Board is forming an ad hoc subcommittee to review the method.

Comment. EPA's risk assessment method is incomplete.

Agency Response. EPA agrees with the comment. As applied to ozone, the risk assessment method assesses the risk (probability) that ozone would contribute to health effects in some sensitive people if alternative standards were just met. A complete risk picture would also include information on:

(a) a best point estimate of the number of people affected;

(a') the "expected number" (in a statistical sense) of people affected;

(a") various risks (probabilities) that the actual number of people affected would be various amounts greater than the expected number;

(b) a best point estimate of the amount of health damage;

(b') the "expected" health damage; and

(b") various risks (probabilities) that the actual health damage would be various amounts greater than the expected health damage.

As noted in the draft EPA document explaining the risk assessment method, there are complex technical problems that must be dealt with in responsibly developing information of this type suitable for use in setting National Ambient Air Quality Standards. EPA is presently developing the capability to generate this type of information and will only consider its risk assessment method complete when the method includes this capability.

Comment. The main problem with the risk assessment method stems from its purpose. Instead of estimating health damage, EPA provides a table of risk numbers without providing an estimate of their health significance; these numbers serve no function.

Agency Response. EPA agrees that the risk estimates provided do not serve the function of estimating health damage, but the Agency does not agree that the estimates are without value. The function of these estimates is to indicate the varying risk (or probability) that some sensitive people would suffer health effects in a given period of time if alternative ozone standards were just met. For each health effect category, the response that is of sufficient concern to be deemed a health effect has been decided upon and its seriousness described. As EPA interprets the Clean Air Act, this determination, which is an important step in the process of setting National Ambient Air Quality Standards, is a function that is to be served by a risk assessment.

There were many comments on both the procedural and the technical aspects of the risk assessment method. EPA will consider these comments in the detailed responses to be placed in the docket. Some of the comments identify improvements that can be made in the risk assessment method, while others reflect misunderstandings that will be dealt with in the detailed docket responses. Some of the comments provide discussion and opinions on various complex issues that arise in the conduct of a program involving the difficult subject areas of risk assessment and standard-setting methodology. EPA will take these comments into advisement as it develops its risk assessment and standard-setting methodologies.

III. WELFARE EFFECTS AND THE SECONDARY STANDARD

Comment. EPA's proposal to retain the existing secondary standard is based entirely on evidence of possible damage to extremely sensitive vegetation. An adequate economic analysis that considers the incremental costs and benefits of alternative secondary standard levels should be conducted. EPA should then weigh the economic costs of pollution control measures against the benefits of reduced damages from lower ozone concentration levels before setting a secondary standard.

Agency Response. The Clean Air Act requires EPA to set a national secondary ambient air quality standard at a level that, in the judgment of the Administrator, is requisite to protect the public welfare from any known or anticipated adverse effects. The term "public welfare," which is defined in Section 302(h) of the Clean Air Act, includes among other things effects on crops, vegetation, wildlife, visibility, and climate, "as well as effects on economic values and on personal comfort and well-being."

EPA has carefully examined the data presented in the criteria document concerning ozone-related damage to vegetation, crops, materials, and visibility. A staff paper, "Evaluation of Alternative Secondary Ozone Air Quality Standards," has been placed in the docket (OAQPS 78-8, IV-A-3).

With regard to damage to materials, the paper concludes that no effect-based rationale can be offered to decide the level of the secondary standard. Damage to materials is linearly related to the total dose sustained by the material. As a result, the annual average concentration will determine the rate at which material damage occurs. Current evidence indicates that annual average concentrations for remote rural areas are comparable to urban areas, due to strong night-time scavenging of ozone in urban areas by man-made pollutants. Reducing the peak 1-hour concentration in urban areas will have virtually no impact on the annual average concentration. Therefore, there would be no measurable reduction in materials damage if a more stringent secondary standard level was selected.

The criteria document states that there is a limited amount of data suggesting an association between ambient ozone and visibility degradation, particularly in the Los Angeles area. On the basis of EPA's evaluation to date of the information presented in the criteria document, however, EPA is unable to conclude at this time that a secondary ozone standard more stringent than the primary standard is necessary to prevent visibility deterioration. The relationship between visibility and abmient ozone will be considered further in the development of subsequent PSD programs designed to protect against significant deterioration of air quality.

Finally, EPA has concluded that there is currently no evidence indicating that a significant decrease in yield or growth or commercially important crops or indigenous vegetation will result from the long-term (growing season) mean of the daily maximum 7-hour-average ozone concentrations which is expected to occur when the primary standard is attained. Consequently, EPA does not believe that a secondary standard more stringent than the primary standard is necessary to protect vegetation from ozone-related yield reduction effects.

On the basis of these conclusions, EPA does not believe that a detailed cost-benefit analysis of alternative standard levels is required, since a secondary standard more stringent than the primary standard is not necessary to protect the public welfare adequately.

Comment. The current secondary standard of 0.08 ppm should be retained to protect vegetation and crops. There is significant reduction in growth and yield to crops exposed to 0.10 ppm of ozone.

Agency Response. The claims that significant reduction in growth and yield occurs in crops as a result of short-term exposures to ozone at levels around 0.10 ppm are undocumented. While sensitive plants may incur foliar injury at low ozone levels, there is currently no evidence that significant yield or growth effects in commerically important crops or indigenous flora are associated with the long-term (growing season) mean of the daily maximum 7-hour-averaging ozone concentrations expected to occur when the primary standard is attained. Consequently, EPA does not believe that a secondary standard more stringent than the primary standard is necessary to prevent ozone-related yield reduction effects in vegetation.

IV. IMPLEMENTATION AND ATTAINABILITY

A. VALUE OF HYDROCARBON CONTROL AND TIMING OF SIP SUBMISSIONS

EPA received comments on the effectiveness of hydrocarbon controls in reducing levels of ozone in the ambient air as well as on the issue of whether or not the statutory deadline for submission of revised State Implementation Plans (SIPs) for nonattainment areas should be postponed because of the changes in the photochemical oxidants standard. The Agency responses to these comments are contained in the accompanying FEDERAL REGISTER notice dealing with the revision of the 40 CFR Part 51 regulations pertaining to the implementation of the standard.

B. CONSIDERATION OF CONTROL COSTS

Comment.

Cost of control should be considered in selecting the level of the primary standard.

Agency Response. The Agency's position with respect to control cost consideration was stated in the preamble to the proposed regulation (43 FR 26963); this position remains unchanged. The Clean Air Act specifies that primary National Ambient Air Quality Standards are to be based on scientific criteria relating to the level that should be attained to protect public health adequately. Considerations of cost of achieving these standards or of the existence of technology to bring about needed reductions of emissions are not germane to such a determination, as the words of the Act and its legislative history clearly indicate. EPA has, however, analyzed the cost and economic impacts of the control programs required to attain alternative ozone standard levels in order that the publc may be better informed of the consequences of the Agency's decision. This analysis and the comments received in response to it are available to the States for their use in developing strategies to implement the standard.

Comment. The cost estimates presented in EPA's cost and economic impact assessment document are understated.

Agency Response. EPA has carefully reviewed and considered these comments and is publishing a revised economic impact assessment, which is available from Mr. Padgett at the previously mentioned address.

C. NATURAL BACKGROUND CONCENTRATIONS

Several comments were made regarding the contribution of natural sources to ambient ozone concentrations. These comments focus on (1) the extent to which natural background was considered in developing the proposed standards and related control programs and (2) the attainability of these standards, considering the possibility that natural background may at times contravene the proposed levels. Some of the comments suggested that EPA ignored, or did not adequately consider, natural background in developing the proposed standards and related control programs. While this topic was not emphasized in the preamble to the proposed rulemaking, EPA was, and is, cognizant of the background levels that can be attributed to natural sources. This matter was treated extensively in the revised criteria document. Furthermore, EPA procedures for preparation of control plans recommend allowance for natural background in developing control strategies for ozone.

For several years, EPA has been conducting an active field and laboratory research program seeking to determine the nature and extent of background concentrations of ozone. The results of these studies have been widely publicized in EPA reports, scientific literature, and public conferences. One comment suggested that EPA had ignored evidence of natural source impacts reported in contract work conducted for the Agency and that this information had not been released for public review. Actually, all pertinent information available to EPA was considered. However, there may have been some contractually developed information that had not been released or could not be specifically cited because the contract studies were still in progress and the resulting data had not been fully validated or analyzed. Subsequent to the comment, all information in question were released publically or arrangements have been made to release them as soon as possible.

EPA's review of data related to the background contribution leads the Agency to conclude that such levels are usually well below the proposed levels of the standard, especially during the season of the most active production of photochemical ozone. It is possible, however, that natural events could occasionally cause contravention of the promulgated standard levels. EPA policy (see 40 CFR 51.12(d)) permits data for such occurrences to be disregarded for regulatory purposes. Such events are usually distinguishable because they tend not to coincide with conditions conducive to buildup of man-caused, photochemically produced ozone. Field measurements at some remote sites, where man-caused ozone is likely to be negligible, have shown low—but not insignificant—rates of exceedances of the 0.08-ppm level originally proposed for the secondary standard. The frequencies decrease markedly for concentrations above 0.12 ppm, so that natural exceedances of the standards being promulgated can be considered quite rare at any particular location.

One comment indicated that stratospheric tracer levels measured at surface sites increase by about 40 percent between the front and back side of high pressure systems in the Eastern United States, thus suggesting that stratospheric ozone, through subsidence and horizontal circulation in highs, plays a significant role in the widespread buildup of ozone that tends to occur in the back side of highs in the Eastern U.S. during the photochemically active season. EPA's estimate is that, even if commonly occurring natural ozone background were increased by 40 percent, the resulting concentration would be insufficient to exceed the standard levels being promulgated. Also, a corresponding increase between the tracer and ozone of stratospheric origin would not be expected, since the tracer is chemically stable near the surface, while ozone is rapidly depleted by reactions with surfaces and with air contaminants.

Some comments referred to a possibly significant contribution to ozone concentrations from reactions involving organic compounds emitted by vegetation. Such emissions are abundant, relative to man-made emissions, but are relatively diffuse spatially. Some of the comments cited a recent statistical study that reported a high correlation between vegetative growth in the Bay Area of California, as indicated by winter rainfall, and the frequency of days with concentrations above 0.08 ppm. EPA has not, however, seen sufficient physical evidence of a relative abundance of natural organics or associated ozone increases in ambient air to consider vegetative sources as significant contributors to high ambient ozone levels. The principal source of natural ozone is still considered to be the stratosphere, with gradual transfer accounting for the more commonly observed background levels, and sporadic intrusions being the principal cause of anomalous high values.

Although research will continue to assess more definitively the contribution of natural sources of ozone, EPA believes that adequate consideration has been given to this issue in developing control programs and implementation guideline documents.

V. PROCEDURAL ISSUES

Comment. EPA's use of an "Advisory Panel on Health Effects of Photochemical Oxidants" was procedurally incorrect in that certain legal requirements on establishment and use of Advisory Committees were not met.

Agency Response. The ad hoc Advisory Panel consisted of a group of medical experts retained by EPA as consultants for the purpose of obtaining their interpretation of the evidence presented in a preliminary version of the criteria document. As such, EPA did not regard the Panel as an advisory body within the meaning of the Advisory Committee Act of 1972. In any case, the Panel's report has been in the docket and subject to comment since proposal, and bases for its recommendations have been fully aired.

Comment. In revising its criteria document, EPA failed to comply with the recommendations of the statutory scientific review body, the Science Advisory Board (SAB), as evidenced by the SAB's refusal to approve the criteria document.

Agency Response. The function of the Science Advisory Board subcommittee is to advise EPA regarding the scientific and technical accuracy, the manner of presentation, and the adequacy of the criteria document. Inevitably, no two scientists ever agree completely on the importance, accuracy and manner of presentation of data. In the final analysis the responsibility for the criteria document rests with EPA and, therefore, the decision regarding the content of the document must also rest with EPA.

EPA solicits the advice of its scientific advisors and has attempted to respond to the specific comments made by members of the SAB subcommittee established to review the criteria document by incorporating suggested changes in the document. Following the last SAB subcommittee meeting in Febrary 1978, members of the subcommittee who had specific comments were consulted by EPA personnel, and their comments and criticisms were discussed with them prior to making the changes in the document. It has always been Agency policy that once the EPA staff had considered the changes suggested by the SAB and, where appropriate, incorporated them into the criteria document, the Agency would proceed with publication. Consequently, EPA feels that the criteria document adequately reflects the latest scientific knowledge pertaining to the effects of ozone and other photochemical oxidants.

Comment. EPA has failed to submit the proposed standard to the SAB for review as required by the Environmental Research, Development, and Demonstration Authorization Act of 1978 (Pub. L. 95-155). EPA should do so before promulgating the standard.

Agency Response. The development of the ozone standard revision, which began in 1976, followed the procedural process in place before the enactment of Public Law 95-155. Accordingly, the SAB was asked to review only the criteria document. The independent committee established in accordance with the 1978 Act held its first session in October 1978, when there was not adequate time for it to review the standard. The thorough review of the technical and scientific basis for the criteria document, which is in turn the basis for the standard, substantially complies with the objectives of the Act.

SELECTING THE LEVEL OF THE PRIMARY STANDARD

EPA's objective in setting the standard level is to select an ozone concentration that will reflect an accurate consideration of the existing medical evidence and an adequate assessment of the uncertainties in this evidence, and, thus, will protect all population groups with an adequate margin of safety.

The criteria document supports the contention that a clear threshold of adverse health effects cannot be identified with certainty for ozone. Rather, there is a continuum consisting of ozone levels at which health effects are certain, through levels at which scientists can generally agree that health effects have been clearly demonstrated, and down to levels at which the indications of health effects are less certain and harder to identify. Given such a body of evidence, in selecting a standard with an adequate margin of safety the decisionmaker is taking into account the uncertainty about whether a possible standard will prevent adverse health effects.

This uncertainty results from several factors. First, human susceptibility to health effects varies, and we cannot be certain that experimental evidence has accounted for the full range of susceptibility. Second, we cannot be certain that all effects occurring at low ozone levels have been identified and demonstrated. Third, variations in weather create uncertainty as to the expected annual maximum ozone concentrations.

The Clean Air Act, as the Administrator interprets it, does not permit him to take factors such as cost or attainability into account in setting the standard; it is to be a standard that will adequately protect public health. He recognizes that controlling ozone to very low levels is a task that will have significant impact on economic and social activities. This recognition causes him to reject as an option the setting of a zero-level standard as an expedient way of protecting public health without having to decide among uncertainties. However, it is public health, and not economic impact, that must be the compelling factor in the decision. Thus, the decision as to what standard protects public health with an adequate margin of safety is based on the uncertainty that any given level is low enough to prevent health effects, and on the relative acceptability of various degrees of uncertainty, given the seriousness of the effects.

In selecting the proper level for the standard, EPA must make assessments and judgments in five critical areas:

1. Reported effect levels from human studies.
2. Characterizing the sensitive population.
3. Nature and severity of effects.
4. Probable adverse health effect level in sensitive persons.
5. Judgment of a standard level below the probable effect level that provides an adequate margin of safety.

REPORTED EFFECT LEVELS

In the preamble to the proposed standard (43 FR 26965), EPA presented a table of demonstrated effect levels in man ranging from 0.15 to 0.30 ppm. On the basis of suggestions received during the comment period, that table has been expanded to include a greater number of studies where effects have been reported. EPA believes that this is a more complete representation of the medical evidence since it includes some less conclusive studies at low levels that cannot be discarded in weighing the full body of health data. Nonetheless, the table must be used with caution and in conjunction with qualifying statements made in the criteria document regarding the technical merit of each study, particularly the less conclusive studies at lower concentrations.

While this table does not provide an undisputed value for adverse health effect levels in sensitive individuals, it does indicate that normal body functions are most likely disrupted at relatively low ozone concentrations. The studies also indicate that the intensity and significance of effects increases as the pollutant level increases. The reported findings leave open the question of increased intensity of effects in more sensitive persons and the concern that effects reported in some studies may occur at lower concentrations when ozone is present in combination with other urban pollutants.

[6560-01-C]

REPORTED EFFECT LEVELS

Compilation of Results Reported in Human Studies Examining Ozone or Oxidant Exposure

Concentration, ppm	Exposure Duration, hours (for clinical studies); Averaging time (for epidemiological studies)	Pollutant Measured (O_3 = ozone, O_x = oxidant)	Reported Effect(s)	Reference(s)
0.01 - 0.30	hourly average	O_3	Lung function parameters in about 25% of Japanese school children tested were significantly correlated with O_3 concentrations (over the range of 0.01 - 0.30 ppm) in the 2 hours prior to testing.	Kagawa and Toyama (1975); Kagawa et al. (1976)
0.03 - 0.30	hourly average	O_x	Although significant correlation was observed between decreased athletic performance and O_x concentrations in the range of 0.03 - 0.30 ppm, the criteria document states that inspection of the data reveals no obvious relationship between performance and O_x values below 0.10-0.15 ppm.	Wayne et al. (1967)
0.10	2	O_3	Decreased O_2 pressure in arterialized blood, increased airway resistance observed using non-standard measurement techniques.	von Nieding et al. (1976)
0.10 - 0.15	probably daily maximum hourly average	O_x	Increased rates of respiratory symptoms and headache were reported by Japanese students on days when O_x concentrations exceeded 0.15 ppm as compared to days when O_x concentrations were less than 0.10 ppm.	Makino and Mizoguchi (1975)
0.15	1	O_3	Subjective symptoms of discomfort were observed by most subjects, and discernible but not statistically significant changes in respiratory patterns occurred while performing vigorous exercise.	DeLucia & Adams (1977)
0.20	3	O_3	Reduction in visual acuity (night vision) observed.	Lagerwerff (1963)
0.20 - 0.25	2	O_3	Asthmatic patients exposed under intermittent light exercise conditions showed no statistically significant changes in respiratory function. Symptom scores increased slightly during O_3 exposures. Small but statistically significant blood biochemical changes occurred.	Linn et al. (1978)
0.25	2	O_3	Small changes in lung function were observed in 3 subjects performing intermittent light exercise.	Hazucha (1973)
0.25	2 and 4	O_3	No lung function changes of note were observed in "reactive" subjects (who had histories of cough, chest discomfort or wheezing associated with air pollution or allergy) while performing intermittent, light exercise.	Hackney et al. (1975)
0.25	daily maximum hourly average	O_x	The average number of asthma patients having attacks was statistically significantly elevated on days when O_x levels exceeded 0.25 ppm.	Schoettlin and Landau (1961)
0.25	0.5 - 1	O_3	Blood samples of exposed subjects had increased rates of sphering of red blood cells	Brinkman et al. (1964)
0.28	daily maximum instantaneous (2-minute) average	O_x	Although the reported results are inconclusive, EPA's examination of the evidence presented suggests exacerbation of asthma when O_x levels are above 0.28 ppm.	Kurata et al. (1976)
0.30	1	O_3	Subjective symptoms of discomfort and statistically significant changes in pulmonary function were observed in subjects undergoing vigorous exercise.	DeLucia and Adams (1977)
0.30	daily maximum hourly average	O_x	Increased rates of cough, chest discomfort, and headache were observed in student nurses on days when the O_x concentrations exceeded 0.30 ppm.	Hammer et al. (1974)
0.37	2	O_3	Discomfort symptoms and significant changes in lung function were observed in subjects undergoing intermittent light exercise.	Hazucha et al. (1973); Folinsbee et al. (1975); Silverman et al. (1976)
0.37 0.37	2 2	O_3 SO_2	Exposure to O_3 and SO_2 together produced changes in lung function substantially greater than the sum of the separate effects of the individual pollutants.	Hazucha and Bates (1975)
0.37 0.37	2 2	O_3 SO_2	The observed O_3 - SO_2 interactive effect on lung function was considerably smaller than that seen by Hazucha and Bates. The authors concluded that the earlier study probably more nearly simulated a smog episode in regions having high oxidant and sulfur pollution.	Bell et al. (1977)

SENSITIVE POPULATION

The legislative history of the Clean Air Act indicates that, in setting primary ambient air quality standards, EPA is to direct its efforts at groups of "particularly sensitive citizens such as bronchial asthmatics and emphysematics who in the normal course of daily activity are exposed to the ambient environment." (U.S. Senate Serial No. 93-18, 93d Cong. 2d Sess. p. 410).

Clinical and epidemiological studies have shown that persons with chronic obstructive airway disease, particularly asthmatics, appear most sensitive to changes in ozone concentrations. This sensitivity results from the fact that their airways are hyper-reactive to irritants such as ozone. These people are, thus, judged to be the principal sensitive group of concern in setting the standard.

Studies have also established that exercise effectively increases the ozone dose delivered to the target tissues in the respiratory tract. Thus, persons engaging in exercise are particularly vulnerable to the acutely irritating effects of ozone. The response of these groups to such changes in concentrations has not, however, been systematically studied.

NATURE AND SEVERITY OF EFFECTS

Impaired Pulmonary Function and Clinical Symptoms—Ozone is a pulmonary irritant that affects the mucous lining, other lung tissue, and respiratory function. Changes in lung function appear as increased airway resistance and as reductions in vital capacity, expiratory flow rates, and diffusion capacity. These effects are greater in exercising individuals and individuals with hyper-reactive airways (i.e., individuals with a history of developing symptoms during light activity in smog or history of asthma). Changes in lung function are accompanied by clinical symptoms such as coughing, chest tightness, and lower chest soreness.

Because the human respiratory system is endowed with a large reserve, even airway-resistance increases of 50 to 100 percent will not ordinarily be perceived in normal individuals. As stated in the criteria document, however, two considerations suggest that oxidant-associated changes in lung function may signal impairment of public health. first, in people with underlying respiratory illness such as asthma, chronic bronchitis, and emphysema, even small decrements in lung function often interfere with normal activity. Second, at experimental ozone concentrations as low as 0.30 ppm, decrements in lung function have usually been accompanied by physical discomfort, as manifested in symptoms such as sore throat, chest pain, cough, and headache. At times this discomfort has been great enough to prevent the completion of experimental protocols, particularly when subjects have been exercising vigorously. It appears quite likely that the pulmonary irritant properties of ozone (and perhaps other oxidants) underlie both the discomfort and the decrements in function. Thus, at least when associated with ozone exposure, changes in lung function often represent a level of discomfort which, even among healthy people, may restrict normal activity or impair the performance of tasks.

Decreased Resistance to Infection—This effect is represented by an increased rate of mortality in laboratory animals subjected to both a bacterial challenge and exposures to ozone. According to some studies, the effect may be enhanced by the addition of such stresses as exercise or the addition of other pollutants in combination with the ozone dose. Despite the uncertainties involved in predicting human effects from animal studies, medical experts agree that decreased resistance to infection probably does occur in man. The Durham study (1974) reporting increased illness in college students following periods of elevated pollution levels (with peak oxidant being the pollution variable most strongly associated with illness) reinforces this hypothesis and adds to EPA's concern about the relationship of ozone to the occurrence of such an effect in man.

Aggravation of Chronic Respiratory Disease—Although the relationship between ambient oxidant or ozone levels and chronic pulmonary disease has not been fully assessed, available evidence suggests that the incidence and severity of asthma attacks increase when short-term total oxidant concentrations exceed 0.25 to 0.28 ppm. Also, several investigators have reported a relationship between short-term oxidant exposure and aggravation of other chronic obstructive lung diseases. However, their reports are inconclusive since short-term fluctuations in cigarette smoking habits were not considered in their data analyses.

Air pollution is one of the many stresses that can precipitate an asthma attack or worsen the disease state in persons with chronic cardiopulmonary disease. Other factors that can precipitate attacks include respiratory infections, passage of cold fronts, seasonal pollens, extreme heat or cold, and emotional disturbances.

Eye Irritation—Eye irritation is associated with selected chemical species (such as PAN) in the photochemical oxidant mix and with other organic vapors. While there is no evidence that eye irritation is produced by ozone, an ozone standard will serve to limit this effect because control measures that reduce ozone will also reduce the eye-irritating components in the total oxidant mix.

Biochemical Effects—Experimental exposures of human subjects to ozone have produced changes in blood biochemistry, such as increased fragility of red blood cells and altered enzyme activities in the serum. The significance of these ozone-mediated changes is not yet known, but the criteria document states that changes of the magnitude observed in human experimental exposures have not yet been linked to any clinical diseases.

Carcinogenic, Mutagenic and Related Effects—Studies have been conducted in an attempt to relate ozone to carcinogenic, mutagenic, and related effects. Available evidence in these areas is not particularly helpful in setting ambient ozone standards because most of the studies have not yet been replicated (in spite of some attempts to do so), and because some effects observed in lower life forms are of questionable significance for man. The criteria document states that the significance of effects such as chromosomal aberations has not been established and that some studies have produced conflicting results. In addition, EPA's Science Advisory Board recommended that certain studies on the mutagenic effects of ozone, which have not been replicated, not be emphasized in the criteria document.

PRIMARY STANDARD

As illustrated in the table of reported effect levels, there is no clear threshold air concentration of ozone indicated by the data as the onset of adverse health effects. It is EPA's best judgment that physiological responses probably occur in extremely sensitive persons at very low levels. At what point these responses become an adverse health effect and at what level they most likely occur in sensitive persons must necessarily be an informed judgment. As stated in the proposal, this judgment is based on (1) the Agency's understanding of the medical evidence presented in the criteria document and in the table of reported effect levels, (2) the findings of the advisory panel on health effects, and (3) the judgment of medical experts as to the adverse effect level in sensitive persons. The health experts who were consulted were asked to focus not only on the most sensitive population group, but also on a very sensitive portion of that group (specifically, those persons who are more sensitive than 99 percent of the sensitive group, but less sensitive than 1 percent of that group). The lowest adverse health effect level estimate cited by the health panel and the median value developed through the expert inter view process are reasonably consistent, ranging from 0.15 to 0.18 ppm. (See table below.) On the basis of the effect levels cited in the criteria document, it is EPA's judgment that the most probable level for adverse health effects in sensitive persons, as well as in healthier (less sensitive) persons who are exercising vigorously, falls in the range of 0.15-0.25 ppm. While the evidence is more convincing and the effects more pronounced at the higher end of this range, the data shows effects of concern at the lower concentration.

PROBABLE EFFECT LEVEL ESTIMATES

[Estimates for Sensitive Population Segments]

	Aggravation of asthma, emphysema, and chronic bronchitis	Reduced resistance to bacterial infection (animal studies)	Reduction in pulmonary function	Chest discomfort and irritation of the respiratory tract.
Health panel judgment of effect level.	0.15-0.25 ppm	Not available	0.15-0.25 ppm	0.15-0.25 ppm
Probable or median effect level as estimated from interviews with health experts (Range of estimates given in parentheses).	0.17 ppm (0.14-0.25 ppm)	0.18 ppm (0.07-0.38 ppm)	0.15 ppm (0.07-0.18 ppm)	0.15 ppm (0.11-0.18 ppm)

In order to set an ambient air quality standard that protects the public health with an adequate margin of safety, EPA must deal with the uncertainty inherent in the judgment that the probable level for adverse effects in sensitive persons is in the range of 0.15-0.25 ppm.

Because the nature and intensity of effects vary from pollutant to pollutant and because medical research produces new and different findings as science progresses, EPA does not believe that a fixed acceptable margin of safety can be established for all pollutants or for a single pollutant over time. Each decision on a standard level must be made on the best evidence available at the time and should include consideration of such factors as:

1. *Concern for more sensitive individuals*—Sensitive persons may respond to ozone differently from the less sensitive persons who generally are tested in clinical studies. Individuals with underlying respiratory illness such as asthma, chronic bronchitis, and emphysema are particularly sensitive to even modest impairments of pulmonary function resulting from ozone exposure. For ethical reasons, clinical investigators normally do not expose persons with these illnesses and thus caution that such studies may not represent the full range of sensitivity to ozone. Also of concern are individuals engaged in vigorous outdoor activity (construction work, tennis, jogging, etc.) where the effects of ozone are enhanced or may occur at lower ambient concentrations.

2. *Pollutant interactions*—There is real concern that effects reported in some ozone studies may occur at lower concentrations and may be enhanced when ozone is present in combination with other urban pollutants. Laboratory studies of a single pollutant (e.g., ozone in clean, filtered air), while important in elucidating physiological effects peculiar to that pollutant, cannot be viewed as providing definitive evidence of the minimum level at which these effects occur when that pollutant is present as only a part of the total insult delivered to an individual in the urban environment. Also of concern are other toxic oxidant species, such as PAN, that are often present with ozone in the ambient photochemical pollution mixture and cause other adverse effects such as eye irritation. Thus, the effects of ozone must be considered in the context of the total environment of the exposed individual; this environment includes concentrations of other pollutants consistent with their maximum allowable levels, high relative humidity, high ambient temperature, and high levels of physical stress.

3. *Long-term deleterious effects of ozone*—Unfortunately, there are few studies that have attempted to document the long-term adverse effect of human exposure to repeated peaks of ozone. Some animal studies do indicate that long-term ozone exposures act as an inducer of biochemical or morphological changes. Some of these changes are transient and, on a short-term basis, may have a physiological significance in that they confer a resistance against further lung injury in an oxidant environment (a similar response has been observed in human clinical studies). Some animal studies have indicated, however, that effects from continued exposure can result in an emphysema-like condition (e.g., P'an et al., 1972).

4. *Animal infectivity studies*—Although evidence of reduced resistance to bacterial infection has not reached the point where it can be meaningfully used to extrapolate concentrations that would similarly affect man, these studies cannot be dismissed in selecting a standard level that provides an adequate margin of safety. Despite the present inability to extrapolate to an effect level in humans, most experts agree that ozone exposures may well result in decreased resistance to infection in humans. Further, it is the kind of effect that is serious enough in its implications to raise a need for caution. Thus, it is prudent public health practice to set a standard more stringent than the probable effect level estimated from human studies, in order to account in some measure for these unquantified, but possibly serious, effects.

5. *Inconclusive studies reporting effects at low levels*—A similar caution is suggested by both the Makino and Mizoguchi epidemiological study and the von Nieding clinical study reporting effects at levels around 0.10 ppm.

6. *Uncertainties arising from air quality variations due to meteorology*—Since EPA's revised standard is statistically based and permits an expected number of allowable violations per year, there is concern about the magnitude of these excursions and how they might impact an exposed sensitive individual.

7. *Effects of calibration procedure change*—Another factor that has been considered in establishing a margin of safety is the variability that exists in the measurement and calibration techniques used in health studies and how these measurements may differ from those made with the ultraviolet (UV) reference calibration procedure being promulgated elsewhere in this issue of the FEDERAL REGISTER. Most of the relevant clinical studies utilized monitoring instruments calibrated with the current (NBKI colorimetric) reference calibration procedure or modifications thereof. EPA's best judgment is that the reference NBKI procedure shows a positive bias of about 10 percent with respect to the UV procedure when these techniques are compared under carefully controlled experimental conditions. However, due to the variability that can reasonably be expected in any clinical exposure monitoring measurements, as well as the uncertainty introduced by the modified calibrations procedures, EPA cannot determine a precise quantitative factor to adjust the findings of these health studies. In the case of the study done by DeLucia and Adams (1977), the authors have indicated to EPA that the reported ozone values

might be high with respect to the UV calibration procedure. While the exact magnitude of any required adjustment in the reported ozone values is uncertain, adjusted values could range from 0.12 to 0.15 ppm for the 0.15 ppm value reported by the authors, and from 0.23 to 0.30 ppm for the 0.30 ppm concentration. EPA will continue its evaluation of this issue through its program of clinical exposure studies.

8. *Findings from the preliminary risk assessment*—The preamble to the proposed standard described a preliminary risk assessment method performed to aid EPA in accurately treating the uncertainties associated with a standard decision. While this method cannot be used at this time as the sole tool for making that decision, the Agency does believe that the findings resulted from this initial application of the method do not permit any relaxation of the standard above 0.12 ppm.

After reviewing the comments received from all segments of the public, including those from the public health community, EPA remains convinced that at levels in the range of 0.15–0.25 ppm, adverse health effects will almost certainly be experienced by significant numbers of sensitive persons. Unless the standard is set somewhat below that level, the Agency would not be exercising that degree of prudence called for by the "adequate margin of safety" requirement of the Clean Air Act. The Administrator must exercise the informed scientific judgment that Congress has authorized him to bring to bear on these difficult problems.

There is no collection of facts or medical evidence that permits selecting an undisputed value for the standard level. EPA proposed a standard of 0.10 ppm, taking several factors into account in providing a margin of safety, as discussed above. Among those were epidemiological studies indicating effects below 0.15 ppm which the criteria document did not fully endorse, but which EPA thought it unwise to disregard. (See 43 FR 26966.) Also considered were animal studies indicating reduced resistance to bacterial infection, although extrapolation to human effects levels is not possible. (*Id.*) During the comment periods, EPA received informed scientific opinion disputing the interpretation and application of such studies. Based on its current understanding of these studies, EPA has concluded that they do not dictate as wide a margin of safety as was established in the proposal. EPA does believe, however, that these studies do suggest the real possibility of significant human adverse health effects below 0.15 ppm. Consequently, the Administrator has determined that a standard of 0.12 ppm is necessary and is sufficiently prudent unless and until further studies demonstrate reason to doubt that it adequately protects public health.

WELFARE EFFECTS AND THE SECONDARY STANDARD

The Clean Air Act mandates the setting of a national secondary ambient air quality standard to protect the public welfare from any known or anticipated adverse effects associated with an air pollutant in the ambient air. Ozone and other photochemical oxidants constitute a form of air pollution that has been shown to affect vegetation and materials and that may have an impact on visibility. The economic loss resulting from current oxidant levels has been estimated to be in the range of several hundred million dollars per year nationwide. Non-quantifiable losses to the natural environment occur as well. A staff paper, "Assessment of Welfare Effects and the Secondary Air Quality Standard for Ozone," was placed in the docket at the time of proposal. The following paragraphs summarize this report and information received after its release.

Exposure of vegetation to harmful levels of ozone may result in leaf injury, decreased growth and yield, or reproductive effects. Visible leaf injury is the most readily detectable and frequently reported symptom of ozone damage; however, it is not an accurate indicator of yield or growth reduction.

In the June 22, 1978, FEDERAL REGISTER proposal (43 FR 26968–26969), it was stated that several investigators suggested that foliar injury rates in the range of 5 to 10 percent could produce detectable reductions in growth or yield, depending on the timing of the injury and other environmental factors. Since proposal of the standard in June, EPA has discussed the matter further with several experts in the field of air pollution damage to vegetation, particularly regarding what level of leaf injury should be of concern in protecting against significant reductions in yield or growth in commercially important crops and indigenous flora. These experts emphasized the uncertainty associated with correlating yield reduction with foliar injury. Some stated that detectable yield reductions would not occur until leaf injury reached values as high as 10 to 20 percent, and others felt that foliar injury was an inappropriate indicator of yield reduction.

The foliar responses of plants to ozone exposures are not linearly dependent on the dose (product of concentration and exposure duration) sustained by the plant. A given dose applied over a short period of time is more damaging than if it were applied over a longer period. EPA used a mathematical model to summarize, for several crops, the experimental results which depict the variation in foliar response with short-term (0.5-hour to 8-hour) ozone exposures. The notice of proposed rulemaking predicted (on the basis of the mathematical model) that a secondary ozone air quality standard set at an hourly average concentration of 0.08 ppm, expected to be exceeded only once per year, would prevent any important commercial crop from receiving more than 3 percent leaf injury. On the basis of this prediction and the aforementioned assumptions regarding the relationship of foliar injury and yield reduction, EPA proposed to set the secondary standard level at 0.08 ppm.

As a result of its further consultations with researchers, EPA decided to reassess the uncertainties associated with the judgments that led to the proposed 0.08 ppm 1-hour average secondary standard. These experts pointed out that there are large uncertainties in the assumptions relating yield reduction to foliar injury. The mathematical model used to predict foliar injury was based on chamber studies, not on studies conducted under field conditions. The experts cautioned that these chamber studies generally represent experimental conditions in which the most sensitive varieties of a given species are used and in which moisture and temperature are optimal for producing injury. In addition, a given short-term dose of ozone, which can produce 5, 10, or even 20 percent foliar injury in a given plant, is unlikely to have an impact on yield unless the plant is exposed during a critical stage in the plant's life cycle.

Consequently, EPA has decided to base its decision on the secondary ozone air quality standard on the information currently available on growth and yield reduction in commercially important crops and indigenous vegetation exposed to ozone under field conditions. As discussed in a staff paper that has been placed in the docket (OAQPS 78-8, IV-A-3), "Evaluation of Alternative Secondary Ozone Air Quality Standards," these data indicate that growth and yield responses are related to the long-term (growing season) mean of the daily maximum 6- to 8-hour-average ozone concentrations. Based on an examination of this information, and the available air quality data, EPA concludes that there is currently no evidence indicating that a significant decrease in growth or yield of commercially important crops or indigenous flora will result from the long-term mean of the daily maximum 7-hour-average ozone concentrations expected to occur when the primary standard is attained. Consequently, EPA believes that a secondary standard more stringent than the primary standard is not necessary on the basis of ozone-related yield reduction effects in vegetation.

Materials damage resulting from ozone can be described as an acceleration of aging processes; for example, rubber cracking, dye fading, and paint weathering. In contrast to the effects of ozone on vegetation, these effects are linearly dependent on the total ozone dose sustained by the material. As a result, the annual average concentration will determine the rate at which material is damaged. Any nonzero ozone concentration (including natural background levels) will contribute to the deterioration of sensitive materials over a sufficient exposure duration. While peak 1-hour ozone concentrations in urban areas tend to be considerably higher than in rural areas remote from man-made emission sources, the annual average concentrations observed in these areas are essentially the same. This finding is believed to be due to the impact of very low urban-area nighttime ozone concentrations on the annual average values; nighttime ozone levels in remote areas are not reduced as much from the daytime levels due to the absence of scavenging by man-made urban pollutants. As peak ozone levels in urban areas are reduced through control of man-made pollutants, scavenging will also be reduced resulting in little if any change in the annual average. Consequently, no effect-based rationale can be offered to decide the level of the secondary standard needed to protect materials. Accordingly, EPA believes that a secondary standard more stringent than the primary standard is not necessary on the basis of ozone damage to materials.

The criteria document states that there is a limited amount of data suggesting an association between ambient ozone and visibility degradation, particularly in the Los Angeles area. On the basis of EPA's evaluation to date of the information presented in the criteria document, however, EPA is unable to conclude at this time that a secondary ozone standard more stringent than the primary standard is necessary to prevent visibility deterioration. The relationship between visibility and ambient ozone will be considered further in the development of subsequent PSD programs designed to protect against significant deterioration of air quality.

On the basis of these conclusions with respect to ozone damage to vegetation and materials and the association of ozone with visibility reduction in some areas, EPA is revising the secondary ozone air quality standard level to 0.12 ppm.

OTHER ASPECTS OF THE STANDARD

On the basis of EPA's evaluation of evidence submitted and comments received during the public review process, no major changes will be made in the following aspects of the proposed standard: (1) Averaging time: 1 hour; (2) chemical species: ozone; (3) form: statistical; and (4) a separate standard for PAN is not being promulgated. As discussed below, changes will be made in (1) the set of hourly averages from which the number of exceedances of the standard level is counted, and (2) the exclusion criteria for missing data.

DAILY MAXIMUM HOURLY AVERAGE INTERPRETATION OF THE STANDARD

The maximum ozone concentrations which will occur in any given time period will vary from one period to the next, even if precursor emissions remain constant. These variations are mainly due to the random nature of meteorological factors which affect the formation and dispersion of ozone in the atmosphere. The present deterministic form of the standard, which permits only a single hourly exceedance of the standard level in any year, inadequately deals with this situation. The risk to public health contributed to by ozone can be managed better if the ozone standard reflects the fact that maximum ozone concentrations are probabilistic in nature. Consequently, EPA is changing the standard to a statistical form that allows one expected exceedance per year.

The proposed standard would have allowed one expected hourly exceedance per year. EPA is further modifying the standard so that the one expected exceedance will be given a daily interpretation; that is, a calendar day will exceed the standard level if the maximum hourly average concentration for the day exceeds the level of the standard. This modification means that a day with two hourly values over the standard level counts as one exceedance of the standard level rather than two; similarly for days with more than two hourly values over the standard level. As was indicated in the proposal notice, the daily interpretation has some advantages and it is evident from the comments received that there is considerable support for the use of this interpretation.

It should be understood that the change to a daily interpretation is not predicated on a reinterpretation of health data. In making this change, EPA is not concluding that 3 hours of exposure above a given level, for example, are no worse than 1 hour of exposure above the same level as long as the 3 hours of exposure occur during the same day. The impact of ozone is related to the total dose delivered to the respiratory tract, and obviously for a given concentration a 3-hour exposure gives a greater dose than a 1-hour exposure. In the case of ozone, the pattern of hourly levels is mainly determined by meteorological fluctuations, and EPA's decision to promulgate a daily standard does not affect meteorological fluctuations. Ozone precursor emissions are not easily manipulated on a short-term basis, so there is little likelihood that emission sources could readily alter emission patterns to take advantage of the daily interpretation.

The change to a daily interpretation does make the standard slightly less stringent, and hence there is a small increase in the risk to health. In general, the reduction in emissions of organic compounds needed to meet the standard under the daily interpretation will be smaller. As discussed in a report placed in the docket (OAQPS 78-8, IV-A-4), the long-term increase in health risk at an average geographical location is estimated to be equivalent to the increase that would result from raising the level of the standard to 0.123 ppm and keeping the hourly interpretation of the number of exceedances.

EXCLUSION CRITERIA FOR MISSION DATA

EPA is additionally modifying the standard with respect to the treatment of missing data. The proposed standard permitted certain missing values to be excluded from the estimated exceedances calculation if either of two exclusion criteria were satisfied. The first criterion recognized the impact of short-term meteorological influences by allowing a missing value to be excluded if the adjacent values were below an arbitrary limit (75 percent of the standard level). This criterion should be relatively easy to incorporate into data-handling schemes and has been retained, although it now applies to daily maximum hourly average values. The second criterion dealt with comparisons with data from the previous 3 years. The purpose of this second criterion was to accommodate situations for which ozone data for a particular season are not available but for which known seasonal patterns of ozone and related meteorological factors make it unlikely that the level of the standard would have been exceeded.

This second criterion would be more difficult to implement because it necessitates the cross-referencing of earlier historical data. For newly established monitors, the historical data needed to invoke this exclusion would not be available. Thus, this second criterion in the proposal is difficult to implement and could be potentially burdensome in geographic areas where the climate makes high ozone values during certain seasons very unlikely. It is also possible to accomplish the intended purpose of this exclusion through provisions of the recently proposed 40 CFR Part 58 (see 43 FR

34892) that would grant waivers of the ozone monitoring requirements for certain times of the year at the discretion of the appropriate Regional Administrator. Therefore, the second exclusion criterion has been eliminated, and the computation formulas for estimating the expected number of exceedances have been modified to reflect the number of required monitoring days for the year.

Definition of When the Standard is Attained—EPA is adding Appendix H to 40 CFR Part 50 to explain when the standard is or is not being attained. Certain modifications to the proposal were necessary to accommodate the daily interpretation and the previously mentioned changes in the treatment of missing data. In order to implement the change from an hourly to a daily interpretation, it is necessary to define what is meant by a valid day of ozone data. Such a definition must ensure that a sufficient number of hours of the day have been monitored and that the hourly values in question reflect the time of day when high ozone values are likely to occur. At the same time, this criterion should be relatively easy to implement, it should allow time for routine maintenance, and yet it should protect against high values being ignored merely because not enough hours of the day were measured. Accordingly, a daily maximum hourly average concentration will be considered valid if 75 percent of the hourly values from 9:01 a.m. to 9:00 p.m. (LST) were recorded or if an hourly value above the level of the standard was measured. This validity criterion is intended as a minimum requirement and not as a recommended schedule.

The computation formula for calculating the estimated number of exceedances per year has been modified to correspond to the daily interpretation of the standard. Allowance has also been made for any situation in which the Regional Administrator has granted a waiver of the ozone monitoring requirements under the provisions of the recently proposed 40 CFR Part 58 and, therefore, the total number of required monitoring days is less than a full year. The use of the exclusion criterion may result in an underestimate of the probability of an exceedance in some situations but is relatively easy to implement and should suffice to account for the effect of missing data. It should be noted that the formula given in Appendix H is necessary to show attainment. Accounting for missing data can never, however, decrease the number of exceedances, and thus it is possible to establish non-attainment without the use of this equation.

These modifications to Appendix H are intended to simplify somewhat the calculations and to allow for more flexible monitoring schedules. The comments received on Appendix H were varied. A few commenters thought it was too complicated while others suggested even more complex techniques. Most cmments were, however, supportive of (or, at least, neutral toward) the proposed approach. One suggestion was to employ a minimum percent completeness requirement, rather than estimating the number of exceedances. The problem with that approach, however, is that it remains unclear as to what should be done with data sets that fail to meet such a completeness requirement.

Some comments discussed the use of 3 years of data. As indicated in the proposal, the choice of a 3-year period represents a compromise between added stability and reasonably current status assessments. Even under the present deterministic form of the standard, attainment designations (e.g., 40 CFR Part 81, Section 107) have been based on more than 1 year. Furthermore, although 3 years are used in estimating the expected number of exceedances under the statistical form of the standard being promulgated, it is still possible to establish non-attainment after one year if, for example, four or more exceedances were reported. Therefore, an upper bound to exceedances during a single year still applies under the new form.

ECONOMIC, ENERGY, AND ENVIRONMENTAL IMPACTS

As has been noted, the Clean Air Act specifically requires that National Ambient Air Quality Standards be based on scientific criteria relating to the level that should be attained to protect public health and welfare adequately. EPA interprets the Act as excluding any consideration of the cost of achieving such a standard in determining the level of the primary standard. However, in compliance with the requirements of Executive Orders 11821 and 11949 and OMB Circular A-107 and with the provisions of the recently issued Executive Order 12044 for rulemaking proceedings that are currently pending, EPA has prepared an analysis of economic impacts associated with efforts to attain this standard.

Ozone air pollution is a pervasive problem throughout the country. Most urban and many rural areas exceed the existing standard. Even with the less stringent standard, most of the major urban areas are not expected to attain the standard in the near term. Control of the organic precursor materials that generate photochemical oxidants is a major effort in this country and a multibillion-dollar program. The existing control program includes measures to reduce organic emissions from automobile and truck exhausts, production of chemical and petroleum products, the drycleaning industry, most painting operations (including the automotive industry), and other industrial operations.

Because the attainment problem in most urban areas is so severe, the relaxation of the standard is not expected to change the level of control requirements in the near term. The move to a 0.12 ppm standard will, however, eliminate the theoretical need for major control programs in many rural and wilderness areas that currently exceed the present standard.

With the relaxation of the standard, EPA's economic impact analysis indicates that most urban areas are expected to achieve the standard by 1987. Even with aggressive control programs, however, it will be very difficult for some urban areas to achieve the standard within the next 10 years.

In addition, a document has been prepared assessing the impacts that efforts to attain the standard may have on the nation's energy requirements. This document examines the extent to which ozone precursors will be controlled by recovery of organic materials that would otherwise be emitted to the atmosphere, with resultant energy savings. Furthermore, an additional energy conservation should result in those areas that utilize transportation control measures to reduce precursor emissions by reducing the total number of vehicle-miles travelled. Because of such energy savings, EPA believes that ozone precursor control measures may well lessen the nation's energy requirements.

Finally, environmental impacts associated with control of oxidant precursors have been examined in a document available in docket number OAQPS 78-8. This study indicates that modifying the current standard should have minimal environmental impacts.

Copies of these analyses of the economic, energy, and environmental impacts involved in the revised ozone standard are available from Joseph Padgett at the address given earlier.

REVISIONS TO PART 50 REGULATIONS

In addition to the revised standard, this action necessitates two other revisions to 40 CFR Part 50 as follows:

1. In Appendix D, as well as in the table of sections for Part 50, the title is revised to read as follows: "Appendix D—Measurement Principle and Calibration Procedure for the Measurement of Ozone in the Atmosphere." The substitution of "ozone" for "photochemical oxidants corrected for interferences due to nitrogen oxides and sulfur dioxide" is a result

of the change in the chemical species designation of the standard.

2. Appendix H, "Interpretation of the National Ambient Air Quality Standards for Ozone," is added because additional guidance is necessary to understand the statistical nature of the revised standard.

REVISIONS TO PART 51 REGULATIONS

Elsewhere in this issue of the FEDERAL REGISTER, three revisions to 40 CFR Part 51 are promulgated concurrently with the revision to the photochemical oxidant standard. They are as follows:

1. The term "photochemical oxidants" is changed to "ozone" throughout Part 51.

2. Section 51.14, "Control strategy: Carbon monoxide, hydrocarbons, photochemical oxidants, and nitrogen dioxide," is revised to (a) allow the states to use any of four analytical techniques in the place of Appendix J to calculate the percent hydrocarbon reduction needed to attain the ozone standard, and (b) require that the states consider background ozone concentrations and ozone transport.

3. Appendix J is deleted from Part 51.

FEDERAL REFERENCE METHOD

The measurement principle and calibration procedure applicable to reference methods for measuring ambient ozone concentrations to determine compliance with the standard are not affected by this rulemaking. Elsewhere in this issue of the FEDERAL REGISTER, however, EPA is replacing (superseding) the current calibration procedure with a new, superior calibration procedure based on ultraviolet photometry. The measurement principle and the current calibration procedure are set forth in Appendix D of 40 CFR Part 50 (as amended in the February 18, 1975, issue of the FEDERAL REGISTER, 40 FR 7042). Reference methods—as well as equivalent methods—for monitoring ozone are designated in accordance with 40 CFR Part 53 (40 FR 7044). A list of all methods designated by EPA as reference or equivalent methods for measuring ozone is available from any EPA regional office, or from EPA, Department E (MD-76), Research Triangle Park, NC 27711.

Dated: January 26, 1979.

DOUGLAS M. COSTLE,
Administrator.

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EPA amends Part 50 of Chapter I, Title 40, of the *Code of Federal Regulations* as follows:

1. Section 50.9 is revised to read as follows:

§ 50.9 National primary and secondary ambient air quality standards for ozone.

(a) The level of the national primary and secondary ambient air quality standards for ozone measured by a reference method based on Appendix D to this part and designated in accordance with Part 53 of this chapter, is 0.12 part per million (235 $\mu g/m^3$). The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 part per million (235 $\mu g/m^3$) is equal to or less than 1, as determined by Appendix H.

2. In Appendix D, as well as in the table of sections for Part 50, the title is revised to read as follows:

APPENDIX D—MEASUREMENT PRINCIPLE AND CALIBRATION PROCEDURE FOR THE MEASUREMENT OF OZONE IN THE ATMOSPHERE

3. Appendix H is added as follows:

APPENDIX H—INTERPRETATION OF THE NATIONAL AMBIENT AIR QUALITY STANDARDS FOR OZONE

1. *General*

This appendix explains how to determine when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm (235 $\mu g/m^3$) is equal to or less than 1. An expanded discussion of these procedures and associated examples are contained in the "Guideline for Interpretation of Ozone Air Quality Standards." For purposes of clarity in the following discussion, it is convenient to use the term "exceedance" to describe a daily maximum hourly average ozone measurement that is greater than the level of the standard. Therefore, the phrase "expected number of days with maximum hourly average ozone concentrations above the level of the standard" may be simply stated as the "expected number of exceedances."

The basic principle in making this determination is relatively straightforward. Most of the complications that arise in determining the expected number of annual exceedances relate to accounting for incomplete sampling. In general, the average number of exceedances per calendar year must be less than or equal to 1. In its simplest form, the number of exceedances at a monitoring site would be recorded for each calendar year and then averaged over the past 3 calendar years to determine if this average is less than or equal to 1.

2. *Interpretation of Expected Exceedances*

The ozone standard states that the expected number of exceedances per year must be less than or equal to 1. The statistical term "expected number" is basically an arithmetic average. The following example explains what it would mean for an area to be in compliance with this type of standard. Suppose a monitoring station records a valid daily maximum hourly average ozone value for every day of the year during the past 3 years. At the end of each year, the number of days with maximum hourly concentrations above 0.12 ppm is determined and this number is averaged with the results of previous years. As long as this average remains "less than or equal to 1," the area is in compliance.

3. *Estimating the Number of Exceedances for a Year*

In general, a valid daily maximum hourly average value may not be available for each day of the year, and it will be necessary to account for these missing values when estimating the number of exceedances for a particular calendar year. The purpose of these computations is to determine if the expected number of exceedances per year is less than or equal to 1. Thus, if a site has two or more observed exceedances each year, the standard is not met and it is not necessary to use the procedures of this section to account for incomplete sampling.

The term "missing value" is used here in the general sense to describe all days that do not have an associated ozone measurement. In some cases, a measurement might actually have been missed but in other cases no measurement may have been scheduled for that day. A daily maximum ozone value is defined to be the highest hourly ozone value recorded for the day. This daily maximum value is considered to be valid if 75 percent of the hours from 9:01 a.m. to 9:00 p.m. (LST) were measured or if the highest hour is greater than the level of the standard.

In some areas, the seasonal pattern of ozone is so pronounced that entire months need not be sampled because it is extremely unlikely that the standard would be exceeded. Any such waiver of the ozone monitoring requirement would be handled under provisions of 40 CFR Part 58. Some allowance should also be made for days for which valid daily maximum hourly values were not obtained but which would quite likely have been below the standard. Such an allowance introduces a complication in that it becomes necessary to define under what conditions a missing value may be assumed to have been less than the level of the standard. The following criterion may be used for ozone:

A missing daily maximum ozone value may be assumed to be less than the level of the standard if the valid daily maxima on both the preceding day and the following day do not exceed 75 percent of the level of the standard.

Let z denote the number of missing daily maximum values that may be assumed to be less than the standard. Then the following formula shall be used to estimate the expected number of exceedances for the year:

$$e=v+[(v/n)*(N-n-z)] \qquad (1)$$

(*Indicates multiplication.)

Where:

e=the estimated number of exceedances for the year,
N=the number of required monitoring days in the year,
n=the number of valid daily maxima,
v=the number of daily values above the level of the standard; and
z=the number of days assumed to be less than the standard level.

*Indicates multiplication.

This estimated number of exceedances shall be rounded to one decimal place (fractional parts equal to 0.05 round up).

It should be noted that N will be the total number of days in the year unless the appropriate Regional Administrator has granted a waiver under the provisions of 40 CFR Part 58.

The above equation may be interpreted intuitively in the following manner. The estimated number of exceedances is equal to the observed number of exceedances (v) plus an increment that accounts for incomplete sampling. There were (N-n) missing values for the year but a certain number of these, namely z, were assumed to be less than the standard. Therefore, (N-n-z) missing values are considered to include possible exceedances. The fraction of measured values that are above the level of the standard is v/n. It is assumed that this same fraction applies to the (N-n-z) missing values and that (v/n)*(N-n-z) of these values would also have exceeded the level of the standard.

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

[FR Doc. 79-4056 Filed 2-7-79; 8:45 am]

[6560-01-M]

[FRL 1018-3]

PART 50—NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS

Calibration of Ozone Reference Methods

AGENCY: U.S. Environmental Protection Agency.

ACTION: Final rule.

SUMMARY: Appendix D to 40 CFR Part 50 prescribes a measurement principle upon which reference methods for the measurement of ozone* in the atmosphere must be based. This appendix also specifies a procedure to be used for calibrating those ozone reference methods. EPA has evidence that another calibration procedure for ozone reference methods is significantly more accurate and less variable than the procedure currently specified in Appendix D. Accordingly, EPA is amending 40 CFR Part 50, Appendix D, to replace (supersede) the current calibration procedure with a superior calibration procedure based on ultraviolet photometry.

EFFECTIVE DATE: This action is effective immediately upon publication because the revised standard to which it applies is immediately effective.

FOR FURTHER INFORMATION CONTACT:

Mr. Larry J. Purdue, Telephone 919-541-2665 (FTS: 629-2665).

ADDRESS: Department E (MD-77), Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

SUPPLEMENTARY INFORMATION:

BACKGROUND

Part 50 of Title 40, Chapter I of the Code of Federal Regulations specifies the National Ambient Air Quality Standards for several air pollutants including ozone. Appendixes to Part 50 provide information concerning the reference methods which are used to measure those pollutants. In particular, Appendix D to Part 50 describes a measurement principle upon which ozone reference methods must be based, and specifies a calibration procedure to be used for calibrating such methods. Previously, the calibration procedure specified by Appendix D was based on assay of ozone with 1% neutral buffered potassium iodide (NBKI) and was known as the "NBKI procedure."

On June 22, 1978, EPA indicated its conclusion that another calibration procedure was clearly superior to the NBKI procedure, and accordingly EPA proposed an amendment to Appendix D to replace the NBKI procedure with the new procedure, based on ultraviolet (UV) photometry (43 FR 26971-26984). The rationale for the proposed amendment was discussed in the preamble to that proposal. Interested persons and organizations were afforded an opportunity to comment on all aspects of the proposed changes. The amendment, revised slightly after consideration of the public comments, is being promulgated today in conjunc-

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*The term "ozone" is used herein to be consistent with another EPA action in this issue of the FEDERAL REGISTER substituting "ozone" for "photochemical oxidants corrected for interferences due to nitrogen oxides and sulfur dioxide," which was formerly used in Part 50.

tion with changes in the ambient air quality standards for photochemical oxidants (ozone) appearing elsewhere in this issue of the FEDERAL REGISTER.

NATURE OF CHANGES

The amendment makes three salient changes to the previous requirements for calibration of ozone reference methods. These are as follows:

(1) The NBKI calibration procedure is superseded by a procedure based on UV photometry for the calibration of reference methods for ozone. Since no National Bureau of Standards (NBS) Standard Reference Material is available for ozone, ozone standard concentrations established via the UV procedure are tantamount to primary ozone standards, and the UV procedure itself is thus referred to as a "UV standard" for ozone.

(2) Independent use of a manual KI procedure known as the "BAKI procedure" in lieu of the UV procedure is allowed for 18 months after the effective date of the amendment, with the recommendation that the BAKI technique be related to a UV standard whenever possible.

(3) The use of alternative procedures as transfer standards is specifically allowed if they meet certain transfer standard performance guidelines set forth by EPA. A transfer standard is any device or procedure which can be referenced to a UV ozone standard and then used at another location to reproduce ozone standards. A practical transfer standard offers some important advantages—such as lower cost, ruggedness, easier operation, or convenience—over direct use of the UV procedure.

NEW UV CALIBRATION PROCEDURE

The new UV calibration procedure is quite simple. After generating a stable, ozone concentration with an ozone generator, the operator assays it by passing all or a portion of the gas flow through the cell of a UV photometer. The photometer readings are then used in a formula to calculate the ozone concentration, which as noted earlier, is effectively a primary ozone standard. Most commercially available photometers do the photometric calculations automatically, and some may also make temperature and pressure corrections automatically. The primary burden on the operator is to insure (1) that the photometer is operating correctly, (2) that the apparatus is set up properly and is clean and leak-free, and (3) that the calculations are complete and accurate. While none of these is particularly difficult, EPA has prepared a Technical Assistance Document which explains these tasks and provides other detailed information about the procedure. This document, which is still in draft form to allow further incorporation of user's comments, is available from the address specified at the beginning of this preamble.

The photometer is obviously of critical importance to the procedure and must have a precision within 0.005 ppm or 3% of the concentration, whichever is greater. While a calibration photometer can be assembled from laboratory components, EPA recommends the purchase of a commerical photometer which is either designed specifically for this calibration procedure, or which can be readily adapted to it. EPA is presently aware of 2 such commercial photometers (available from Dasibi Environmental Corp., Glendale, California, and Science Applications, Inc., La Jolla, California) and expects others will become available in the future.

UV photometers of the type used in ambient ozone analyzers are likely to be suitable as calibration photometers. Conversion of an ambient UV analyzer to a calibration photometer is covered in the Technical Assistance Document mentioned above. However, it is important to differentiate between the use of a UV photometer as an ambient analyzer and its use as a calibration photometer. This distinction is predicated more on operational differences than on any specific physical differences. The new calibration procedure requires that a photometer used for calibration must be dedicated exclusively to such use, must be maintained under meticulous conditions, and must be used only with clean, calibration gases. UV analyzers used for ambient monitoring should always be calibrated with an independent calibration photometer or a certified transfer standard. A UV analyzer should not be considered to be "self-calibrated" even though it contains a UV photometer which meets the specifications of the UV calibration procedure.

NEW BAKI CALIBRATION PROCEDURE

The New BAKI calibration procedure is very similar to the previously specified NBKI procedure. Relatively minor modifications provide somewhat less variability than the NBKI procedure. Agencies which are familiar with the NBKI procedure should have no difficulty switching to the BAKI procedure. Independent use of the BAKI prodecure is allowed only for direct calibration of ozone analyzers (not transfer standards) on a temporary basis during the 18-month transition period to permit agencies to adopt the new, UV calibration procedure. Nevertheless, the BAKI procedure has more variability than the UV procedure. Therefore, EPA would urge agencies to adopt the UV procedure as soon as practical. And, when possible, the BAKI procedure should be related to the UV procedure to improve the overall accuracy.

Following the 18-month period, the BAKI procedure will not be authorized for independent use, but can be used as a transfer standard. As such, it must be related to the UV procedure, and its variability and accuracy must be monitored and controlled. Thus, agencies which find the BAKI procedure advantageous could continue to use this procedure as a transfer standard.

TRANSFER STANDARDS

EPA is specifically allowing transfer standards for calibrating ozone analyzers, and has noted a number of advantages which can be realized by their use. Transfer standards for ozone can include procedural techniques such as BAKI and gas phase titration, as well as devices such as ozone analyzers and stable ozone generators. EPA recommends that agencies consider the use of transfer standards where advantageous. But transfer standards must meet certain performance specifications, and their performance must be monitored. EPA has prepared a Technical Assistance Document on "Transfer Standards for Calibration of Ambient Air Monitoring Analyzers for Ozone," which gives the required performance specifications and general guidance on the certification and use of any type of transfer standard for ozone. This document is also still in draft form to allow incorporation of further user's comments, and a copy of it may be obtained from the address given at the beginning of this preamble.

SUMMARY OF COMMENTS RECEIVED AND CHANGES MADE TO FINAL AMENDMENT

Comments relative to the proposed amendment (43 FR 26971) were received from 26 respondents representing EPA Regional Offices, State and local air pollution control agencies, industrial corporations, and other organizations. Almost all of the respondents expressed general support for the proposed change to the UV photometric calibration procedure. Other comments ranged from issues of basic policy to technical aspects of the proposed amendment. After consideration of all the comments, several minor revisions and improvements were made to the proposed amendment, although the basic principles and objectives have not been altered. Specific changes to the proposed amendment are discussed briefly below.

A document containing a summary of all the comments received, the identity of the respondents, the resulting changes made to the amendment, and the rationale for adoption or rejection of each comment is available from the address given at the beginning of this preamble. This document will also be added to Docket No. OAQPS 78-8, which is available for public inspection during normal business hours at the USEPA, Central Docket Section, Room 2903, 401 M Street, SW., Washington, D.C. 20460.

Several respondents pointed to the relatively high cost of implementing the change in calibration procedures and suggested that EPA should either provide the necessary funds to those agencies with nonattainment and unclassified areas, or make available, in each EPA Region, a reference photometer that could be used to certify appropriate transfer standards. Other comments suggested a similar need for such reference photometers until such time that commercial photometers become more generally available. EPA agrees with these general comments and intends to pursue them, but this requires no actual change to the amendment as proposed.

Many of the comments indicated a concern for a lack of reliability in present commercial UV systems. Some of these same respondents recommended revisions in the UV calibration procedure to incorporate procedures for checking or calibrating the photometer's wavelength, path length, and optical density (or absorbancy). However, EPA believes that the reliability of most commercial photometers will be adequate. The photometer specifications require a non-dispersive optical system which is not likely to experience changes in the wavelength. Path length is normally fixed and should be adequately specified by the photometer manufacturer. Optical density checks with neutral density filters (for example) are not practical because of the extremely small optical density range over which the photometer normally operates. The only practical way to check the response of the photometer is with an absorbing gas such as ozone. The linearity test described in Section 5.2.3 serves this purpose.

There was some concern for whether the absorption coefficient of ozone at 254 nm (given in the procedure as 308 ± 4 atm^{-1} cm^{-1} at 0°C and 760 torr) might be different at different temperatures. Other comments indicated that the corrections for temperature and pressure in the UV photometric assay procedure were not always clear. The absorption coefficient of ozone is, in fact, quite insensitive to temperature between 0 and 40°C—aside from the normal effect of gas density change with temperature. For photometers used at temperatures and pressures other than 0° and 760 torr, corrections are required according to the perfect gas laws. Efforts are being made to further clarify these correction procedures in the ozone calibration Technical Assistance Document mentioned earlier.

A series of comments from one respondent recommended revisions to the proposed procedure to more clearly allow the use of other UV photometer designs and other configurations of components within the UV calibration system. It was further pointed out that, with certain configurations, some of the components shown in the suggested configuration might not be necessary, and some of the procedural steps in the proposed procedure might not be necessary or even possible. This respondent questioned whether UV photometer linearity tests by the user are necessary if the manufacturer of the photometer has done the tests. Modification of the commercial photometer might be necessary to carry out the tests and any resultant leaks in the system or improper dilution techniques might confuse the results.

In response to these comments, EPA has revised Sections 3, 3.2, and 5.3 somewhat to more explicitly allow alternate systems or system configurations and to provide for appropriate variations in the procedural steps to accommodate such systems. Also, Section 5.2.3 on linearity has been changed to allow acceptance of the manufacturer's linearity test in lieu of the user-conducted test if the manufacturer can show that the linearity error is less than 3%. When the user carries out the test, the error specification remains at 5% to allow for some variation in the necessary flow measurements.

There were several comments regarding the BAKI calibration procedure and its use for an interim period of 18 months. One respondent questioned the wisdom of changing from a known procedure (NBKI) to an unknown procedure (BAKI) and then changing again to UV photometry within 18 months. The respondent recommended that EPA allow the continued use of the NBKI procedure on an interim basis until the change to UV photometry can be implemented. Another respondent questioned the necessity of allowing the considerably more variable (than UV photometry) BAKI procedure for the interim period, and recommended that comments from State and local agencies directly affected should guide EPA in this area.

EPA agrees that the BAKI procedure is more variable than the UV procedure but believes that some transition period is necessary before the UV procedure is required exclusively. There were few comments to the contrary. EPA considered allowing continued use of the NBKI procedure during the transition period, but the BAKI procedure is really only a slightly modified version of the NBKI procedure and is thus very similar. Since the change from NBKI to BAKI is so easily made, and the performance of the BAKI procedure is significantly better than the NBKI procedure, EPA feels the interim change to BAKI is adequately justified.

A few relatively minor changes were made to the BAKI procedure in Sections 1, 3.8, 4.4.4, and 4.4.5 where respondents suggested a need for clarification or where various improvements to the method could be realized. For example, the units given as "eq" in equation 5a of the BAKI were changed to "equivalents" in order that they not be confused with equivalent weight. Also, the concentration of the hydrogen peroxide added in Section 3.8 has been increased slightly and the specification for the resulting absorbance increase has been reduced from 0.010 to 0.008. Furthermore the calibration slope specification in Section 4.4.5 has been changed from 25,800±600 to 26,000±780.

While several respondents endorsed the use of transfer standards in general, one respondent questioned the advisability of allowing the use of transfer standards based on methods known to be highly variable even under ideal conditions. EPA still believes that the variability of such transfer standards will be adequately controlled by the qualification and certification requirements on transfer standards described in the transfer standard Technical Assistance Document mentioned previously. Hence, EPA has made no major changes to the transfer standard concept as originally proposed.

In regard to EPA's statement that no factor is available to "correct" previously collected ozone measurements to make them comparable to the new UV standard, one respondent thought that EPA should allow individual states or Regions to make corrections to their previously obtained ozone air quality data if they have consistent comparative data for the NBKI and UV photometric calibration techniques. EPA has re-evaluated this position, but as noted below, still discourages such attempted corrections.

EFFECT ON NATIONAL AMBIENT AIR QUALITY STANDARD FOR OZONE

Because of the substantial variability of the NBKI procedure and the unpredictable bias results reported by various investigators, the exact magnitude of any universal bias which may exist between the NBKI and UV procedures cannot be determined. However, available data suggest that any such bias probably does not exceed 10% on the average. For this reason, EPA believes that supersession of the NBKI calibration procedure with the UV procedure should have no effect on the magnitude of the National Ambient Air Quality Standard for Ozone (being revised elsewhere in this issue of the FEDERAL REGISTER). And for the same reason, EPA discourages any attempt to "correct" or "adjust" previously obtained oxidant or ozone measurements to make them "comparable" to measurements based on the new UV calibration procedure—even when individual agencies or laboratories try to determine a more precise, laboratory-specific bias value.

EFFECT ON CURRENTLY DESIGNATED REFERENCE AND EQUIVALENT METHODS

As noted in the June 22 proposal, a change in the calibration procedure specified in Appendix D of 40 CFR Part 50 does not affect the design or performance characteristics of existing reference methods for ozone. The only effect of the change is on the calibration procedure described in the operation manuals associated with the analyzers. EPA will allow a 6-month period of time after final promulgation for manufacturers to revise their manuals, have the revised manuals approved by EPA, and distribute revised manuals (or manual supplements) to all analyzer owners.

The two equivalent methods for ozone designated to date prescribe the NBKI calibration procedure. Because the UV calibration procedure and the transfer standard concept are as beneficial to equivalent methods as they are for reference methods, EPA will also request that the manufacturers of the two equivalent methods revise their respective manuals to specify the UV procedure or certified transfer standards for calibration. EPA believes that, under the circumstances, such a modification to equivalent methods for ozone is desirable and appropriate and should not jeopardize their designated status. Conversely, failure to make such a change may be considered by EPA as possible grounds for cancellation of the equivalent method designation under 40 CFR 53.11. If all manufacturers respond promptly to this request for appropriate manual changes, there will be no impact (other than the change in calibration procedure itself) to owners of designated ozone analyzers.

REVISION ADOPTED

Accordingly, with the final changes as described above, Appendix D of 40 CFR Part 50 is revised as set forth below.

Dated: January 26, 1979.

DOUGLAS M. COSTLE,
Administrator.

Part 50 of Title 40, Code of Federal Regulations is amended as follows:

1. Appendix D is revised to read as follows:

APPENDIX D—MEASUREMENT PRINCIPLE AND CALIBRATION PROCEDURE FOR THE MEASUREMENT OF OZONE IN THE ATMOSPHERE

AUTHORITY:

Section 109, 301 of the Clean Air Act as amended (42 USC 57409, 7601).

MEASUREMENT PRINCIPLE

1. Ambient air and ethylene are delivered simultaneously to a mixing zone where the ozone in the air reacts with the ethylene to emit light, which is detected by a photomultiplier tube. The resulting photocurrent is amplified and is either read directly or displayed on a recorder.

2. An analyzer based on this principle will be considered a reference method only if it has been designated as a reference method in accordance with Part 53 of this chapter and calibrated as follows:

CALIBRATION PROCEDURE

1. Principle. The calibration procedure is based on the photometric assay of ozone (O_3) concentrations in a dynamic flow system. The concentration of O_3 in an absorption cell is determined from a measurement of the amount of 254 nm light absorbed by the sample. This determination requires knowledge of (1) the absorption coefficient (α) of O_3 at 254 nm, (2) the optical path length (l) through the sample, (3) the transmittance of the sample at a wavelength of 254 nm, and (4) the temperature (T) and pressure (P) of the sample. The transmittance is defined as the ratio I/I_0, where I is the intensity of light which passes through the cell and is sensed by the detector when the cell contains an O_3 sample, and I_0 is the intensity of light which passes through the cell and is sensed by the detector when the cell contains zero air. It is assumed that all conditions of the system, except for the contents of the absorption cell, are identical during measurement of I and I_0. The quantities defined above are related by the Beer-Lambert absorption law,

$$\text{Transmittance} = \frac{I}{I_0} = e^{-\alpha c l} \qquad (1)$$

where:

α=absorption coefficient of O_3 at 254 nm=308±4 atm^{-1} cm^{-1} at 0°C and 760 torr.(1, 2, 3, 4, 5, 6, 7)
c=O_3 concentration in atmospheres
l=optical path length in cm

In practice, a stable O_3 generator is used to produce O_3 concentrations over the required range. Each O_3 concentration is determined from the measurement of the transmittance (I/I_0) of the sample at 254 nm with a photometer of path length l and calculated from the equation,

$$c(\text{atm}) = -\frac{1}{\alpha l}(\ln I/I_0) \qquad (2a)$$

or,

$$c(\text{ppm}) = -\frac{10^6}{\alpha l}(\ln I/I_0) \qquad (2b)$$

The calculated O_3 concentrations must be corrected for O_3 losses which may occur in the photometer and for the temperature and pressure of the sample.

2. Applicability. This procedure is applicable to the calibration of ambient air O_3 analyzers, either directly or by means of a transfer standard certified by this procedure. Transfer standards must meet the requirements and specifications set forth in Reference 8.

3. Apparatus. A complete UV calibration system consists of an ozone generator, an output port or manifold, a photometer, an appropriate source of zero air, and other components as necessary. The configuration must provide a stable ozone concentration at the system output and allow the photometer to accurately assay the output concentration to the precision specified for the photometer (3.1). Figure 1 shows a commonly used configuration and serves to illustrate the calibration procedure which follows. Other configurations may require appropriate variations in the procedural steps. All connections between components in the calibration system downstream of the O_3 generator should be of glass, Teflon, or other relatively inert materials. Additional information regarding the assembly of a UV photometric calibration apparatus is given in Reference 9. For certification of transfer standards which provide their own source of O_3, the transfer standard may replace the O_3 generator and possibly other components shown in Figure 1; see Reference 8 for guidance.

3.1 UV photometer. The photometer consists of a low-pressure mercury discharge lamp, (optional) collimation optics, an absorption cell, a detector, and signal-processing electronics, as illustrated in Figure 1. It must be capable of measuring the transmittance, I/I_0, at a wavelength of 254 nm with sufficient precision such that the standard deviation of the concentration measurements does not exceed the greater of 0.005 ppm or 3% of the concentration. Because the low-pressure mercury lamp radiates at several wavelengths, the photometer must incorporate suitable means to assure that no O_3 is generated in the cell by the lamp, and that at least 99.5% of the radiation sensed by the detector is 254 nm radiation. (This can be readily achieved by prudent selection of optical filter and detector response characteristics.) The length of the light path through the absorption cell must be known with an accuracy of at least 99.5%. In addition, the cell and associated plumbing must be designed to minimize loss of O_3 from contact with cell walls and gas handling components. See Reference 9 for additional information.

3.2 Air flow controllers. Devices capable of regulating air flows as necessary to meet the output stability and photometer precision requirements.

3.3 Ozone generator. Device capable of generating stable levels of O_3 over the required concentration range.

3.4 Output manifold. The output manifold should be constructed of glass, Teflon, or other relatively inert material, and should be of sufficient diameter to insure a negligible pressure drop at the photometer connection and other output ports. The system must have a vent designed to insure atmospheric pressure in the manifold and to prevent ambient air from entering the manifold.

3.5 Two-way valve. Manual or automatic valve, or other means to switch the photometer flow between zero air and the O_3 concentration.

3.6 Temperature indicator. Accurate to ±1°C.

3.7 Barometer or pressure indicator. Accurate to ±2 torr.

4. Reagents.

4.1 Zero air. The zero air must be free of contaminants which would cause a detectable response from the O_3 analyzer, and it should be free of NO, C_2H_4, and other species which react with O_3. A procedure for generating suitable zero air is given in Reference 9. As shown in Figure 1, the zero air supplied to the photometer cell for the I_o reference measurement must be derived from the same source as the zero air used for generation of the ozone concentration to be assayed (I measurement). When using the photometer to certify a transfer standard having its own source of ozone, see Reference 8 for guidance on meeting this requirement.

5. Procedure.

5.1 General operation. The calibration photometer must be dedicated exclusively to use as a calibration standard. It should always be used with clean, filtered calibration gases, and never used for ambient air sampling. Consideration should be given to locating the calibration photometer in a clean laboratory where it can be stationary, protected from physical shock, operated by a responsible analyst, and used as a common standard for all field calibrations via transfer standards.

5.2 Preparation. Proper operation of the photometer is of critical importance to the accuracy of this procedure. The following steps will help to verify proper operation. The steps are not necessarily required prior to each use of the photometer. Upon initial operation of the photometer, these steps should be carried out frequently, with all quantitative results or indications recorded in a chronological record either in tabular form or plotted on a graphical chart. As the performance and stability record of the photometer is established, the frequency of these steps may be reduced consistent with the documented stability of the photometer.

5.2.1 Instruction manual: Carry out all set-up and adjustment procedures or checks as described in the operation or instruction manual associated with the photometer.

5.2.2 System check: Check the photometer system for integrity, leaks, cleanliness, proper flowrates, etc. Service or replace filters and zero air scrubbers or other consumable materials, as necessary.

5.2.3 Linearity: Verify that the photometer manufacturer has adequately established that the linearity error of the photometer is less than 3%, or test the linearity by dilution as follows: Generate and assay an O_3 concentration near the upper range limit of the system (0.5 or 1.0 ppm), then accurately dilute that concentration with zero air and reassay it. Repeat at several different dilution ratios. Compare the assay of the original concentration with the assay of the diluted concentration divided by the dilution ratio, as follows

$$E = \frac{A_1 - A_2/R}{A_1} \times 100\% \qquad (3)$$

where:

E=linearity error, percent
A_1=assay of the original concentration
A_2=assay of the diluted concentration
R=dilution ratio=flow of original concentration divided by the total flow

The linearity error must be less than 5%. Since the accuracy of the measured flowrates will affect the linearity error as measured this way, the test is not necessarily conclusive. Additional information on verifying linearity is contained in Reference 9.

5.2.4 Intercomparison: When possible, the photometer should be occasionally intercompared, either directly or via transfer standards, with calibration photometers used by other agencies or laboratories.

5.2.5 Ozone losses: Some portion of the O_3 may be lost upon contact with the photometer cell walls and gas handling components. The magnitude of this loss must be determined and used to correct the calculated O_3 concentration. This loss must not exceed 5%. Some guidelines for quantitatively determining this loss are discussed in Reference 9.

5.3 Assay of O_3 concentrations.

5.3.1 Allow the photometer system to warm up and stabilizer.

5.3.2 Verify that the flowrate through the photometer absorption cell, F allows the cell to be flushed in a reasonably short period of time (2 liter/min is a typical flow). The precision of the measurements is inversely related to the time required for flushing, since the photometer drift error increases with time.

5.3.3 Insure that the flowrate into the output manifold is at least 1 liter/min greater than the total flowrate required by the photometer and any other flow demand connected to the manifold.

5.3.4 Insure that the flowrate of zero air, F_z, is at least 1 liter/min greater than the flowrate required by the photometer.

5.3.5 With zero air flowing in the output manifold, actuate the two-way valve to allow the photometer to sample first the manifold zero air, then F_z. The two photometer readings must be equal ($I=I_o$).

NOTE.—In some commercially available photometers, the operation of the two-way valve and various other operations in section 5.3 may be carried out automatically by the photometer.

5.3.6 Adjust the O_3 generator to produce an O_3 concentration as needed.

5.3.7 Actuate the two-way valve to allow the photometer to sample zero air until the absorption cell is thoroughly flushed and record the stable measured value of I_o.

5.3.8 Actuate the two-way valve to allow the photometer to sample the ozone concentration until the absorption cell is thoroughly flushed and record the stable measured value of I.

5.3.9 Record the temperature and pressure of the sample in the photometer absorption cell. (See Reference 9 for guidance.)

5.3.10 Calculate the O_3 concentration from equation 4. An average of several determinations will provide better precision.

$$[O_3]_{OUT} = \left(\frac{-1}{\alpha \ell} \ln \frac{I}{I_o}\right) \left(\frac{T}{273}\right) \left(\frac{760}{P}\right) \times \frac{10^6}{L} \qquad (4)$$

where:

$[O_3]_{OUT}$=O_3 concentration, ppm
α=absorption coefficient of O_3 at 254 nm=308 atm^{-1} cm^{-1} at 0°C and 760 torr
l=optical path length, cm
T=sample temperature, K
P=sample pressure, torr
L=correction factor for O_3 losses from 5.2.5=(1-fraction O_3 lost).

NOTE.—Some commercial photometers may automatically evaluate all or part of equation 4. It is the operator's responsibility to verify that all of the information required for equation 4 is obtained, either automatically by the photometer or manually. For "automatic" photometers which evaluate the first term of equation 4 based on a linear approximation, a manual correction may be required, particularly at higher O_3 levels. See the photometer instruction manual and Reference 9 for guidance.

5.3.11 Obtain additional O_3 concentration standards as necessary by repeating steps 5.3.6 to 5.3.10 or by Option 1.

5.4 Certification of transfer standards. A transfer standard is certified by relating the output of the transfer standard to one or more ozone standards as determined according to section 5.3. The exact procedure varies depending on the nature and design of the transfer standard. Consult Reference 8 for guidance.

5.5 Calibration of ozone analyzers. Ozone analyzers are calibrated as follows, using ozone standards obtained directly according to section 5.3 or by means of a certified transfer standard.

5.5.1 Allow sufficient time for the O_3 analyzer and the photometer or transfer standard to warmup and stabilize.

5.5.2 Allow the O_3 analyzer to sample zero air until a stable response is obtained and adjust the O_3 analyzer's zero control. Offsetting the analyzer's zero adjustment to +5% of scale is recommended to facilitate observing negative zero drift. Record the stable zero air response as "Z".

5.5.3 Generate an O_3 concentration standard of approximately 80% of the desired upper range limit (URL) of the O_3 analyzer. Allow the O_3 analyzer to sample this O_3 concentration standard until a stable response is obtained.

5.5.4 Adjust the O_3 analyzer's span control to obtain a convenient recorder response as indicated below:

$$\text{recorder response (\% scale)} = \left(\frac{[O_3]_{OUT}}{URL} \times 100\right) + Z \qquad (5)$$

where:

URL=upper range limit of the O_3 analyzer, ppm
Z=recorder response with zero air, % scale

Record the O_3 concentration and the corresponding analyzer response. If substantial adjustment of the span control is necessary, recheck the zero and span adjustments by repeating steps 5.5.2 to 5.5.4.

5.5.5 Generate several other O_3 concentration standards (at least 5 others are recommended) over the scale range of the O_3 analyzer by adjusting the O_3 source or by Option 1. For each O_3 concentration standard, record the O_3 and the corresponding analyzer response.

5.5.6 Plot the O_3 analyzer responses versus the corresponding O_3 concentrations and draw the O_3 analyzer's calibration curve or calculate the appropriate response factor.

5.5.7 *Option 1:* The various O_3 concentrations required in steps 5.3.11 and 5.5.5 may be obtained by dilution of the O_3 concentration generated in steps 5.3.6 and 5.5.3. With this option, accurate flow measurements are required. The dynamic calibration system may be modified as shown in Figure 2 to allow for dilution air to be metered in downstream of the O_3 generator. A mixing chamber between the O_3 generator and the output manifold is also required. The flowrate through the O_3 generator (F_o) and the dilution air flowrate (F_D) are measured with a reliable flow or volume standard traceable to NBS. Each O_3 concentration generated by dilution is calculated from:

$$[O_3]'_{OUT} = [O_3]_{OUT} \left(\frac{F_0}{F_0 + F_D}\right) \qquad (6)$$

where:

$[O_3]'_{OUT}$=diluted O_3 concentration, ppm
F_o=flowrate through the O_3 generator, liter/min
F_D=diluent air flowrate, liter/min

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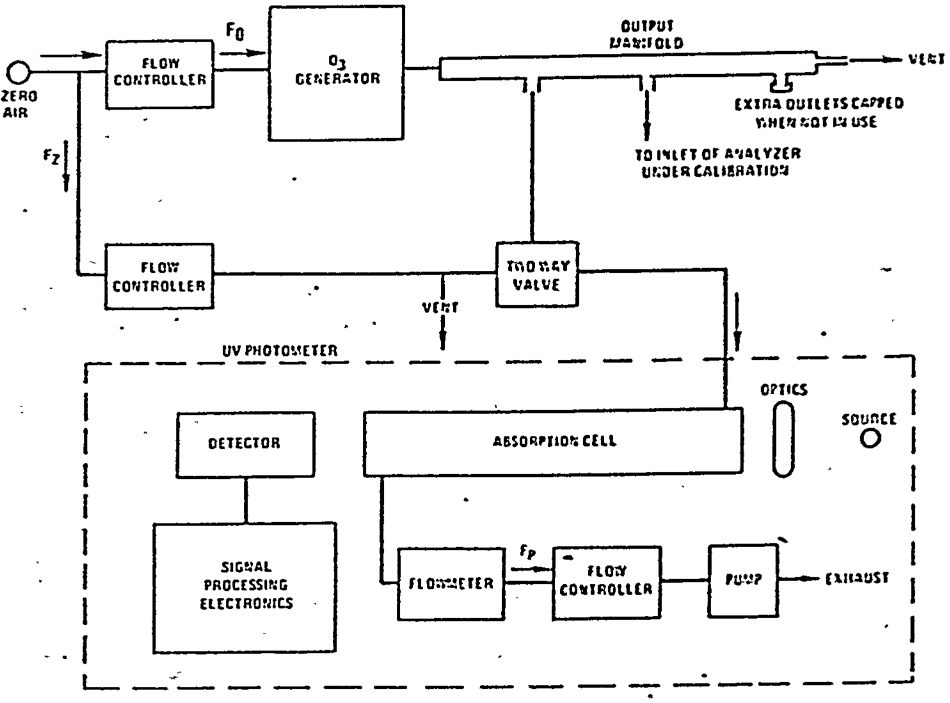

Figure 1 Schematic diagram of a typical UV photometric calibration system

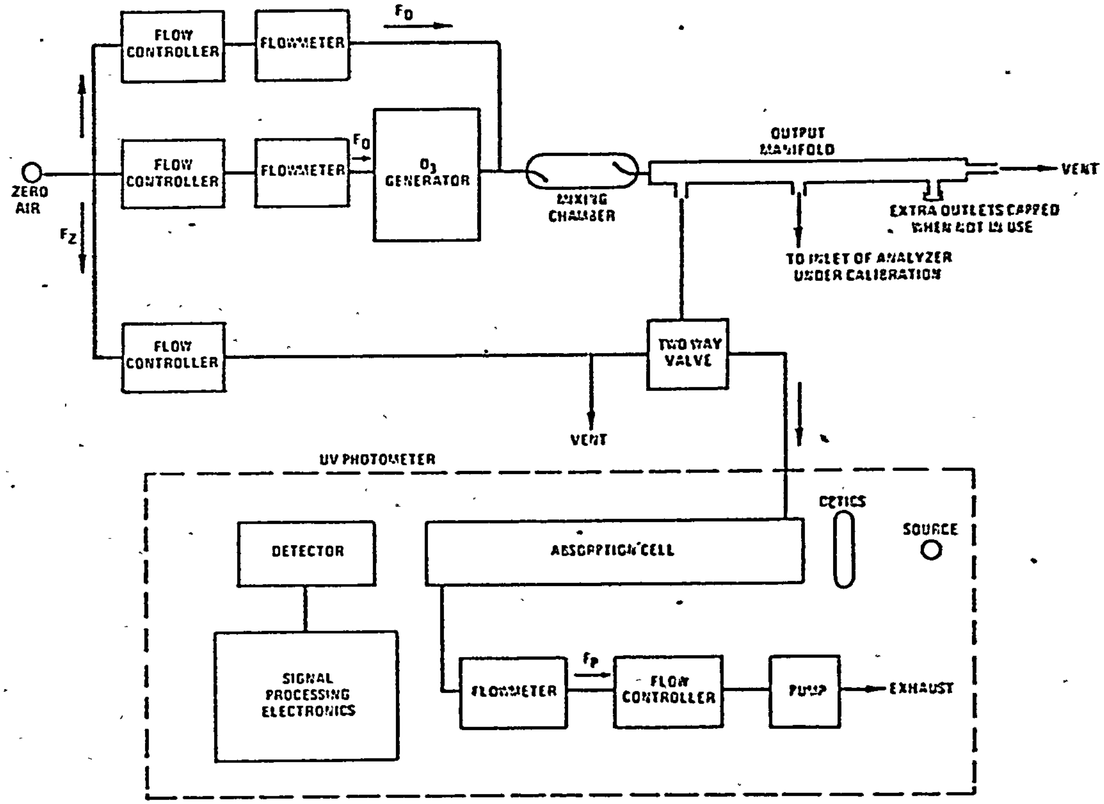

Figure 2. Schematic diagram of a typical UV photometric calibration system (OPTION 1)

Temporary Alternative Calibration procedure—(Boric Acid-Potassium Iodide). This procedure may be used as an alternative to the Ultraviolet Photometry procedure for direct calibration of ozone analyzers—but not to certify transfer standards—until [18 months after the date of final promulgation]. After that time this procedure can be used only as a transfer standard in accordance with the guidance and specifications set forth in Reference 4, "Transfer Standards for Calibration of Ambient Air Monitoring Analyzers for Ozone".

1. Principle. This calibration procedure (1) is based upon the reaction between ozone (O_3) and potassium iodide (KI) to release iodine (I_2) according to the stoichiometric equation: (2)

$$O_3 + 2I^- + 2H^+ \rightarrow I_2 + H_2O + O_2$$

The stoichiometry is such that the amount of I_2 released is equivalent to the amount of O_3, absorbed. Ozone is absorbed in a 0.1M boric acid (H_3BO_3) solution containing 1% KI, and the I_2 released reacts with excess iodide ion (I^-) to form triiodide ion (I^-_3) which is measured spectrophotometrically at a wavelength of 352 nm. The output of a stable O_3 generator is assayed in this manner, and the generator is immediately used to calibrate the O_3 analyzer. The O_3 generator must be used immediately after calibration and without physical movement, and it is recalibrated prior to each use. Alternatively, the O_3 analyzer may be calibrated by assaying the O_3 concentrations using the prescribed procedure while simultaneously measuring the corresponding O_3 analyzer responses. Ozone concentration standards may also be generated by an optional dilution technique. With this option, the highest O_3 concentration standard is assayed using the prescribed procedure. The additional O_3 concentration standards required are then obtained by dilution.

2. Apparatus. Figures 1 and 2 illustrate a typical BAKI O_3 calibration system and show the suggested configuration of the components listed below. All connections between components downstream of the O_3 generator should be of glass, Teflon or other relatively inert material.

2.1 Air flow controller. Device capable of maintaining a constant air flowrate through the O_3 generator within ±2%.

2.2 Air flowmeter. Calibrated flowmeter capable of measuring and monitoring the air flowrate through the O_3 generator within ±2%.

2.3 Ozone generator. Device capable of generating stable levels of O_3 over the required concentration range.

2.4 Output manifold. The output manifold should be constructed of glass, Teflon, or other relatively inert material and should be of sufficient diameter to insure a negligible pressure drop at the analyzer connection. The system must have a vent designed to insure atmospheric pressure in the manifold and to prevent ambient air from entering the manifold.

2.5 Impingers. All glass impingers with the specifications indicated in Figure 2 are recommended. The impingers may be purchased from most major glassware suppliers. Two impingers connected in series are used to insure complete collection of the sample.

2.6 Air pump and flow controller. Any pump and flow control device capable of maintaining a constant flowrate of 0.4–0.6 liter-min through the impingers may be used. A critical orifice as described by Lodge *et al.* (3) is recommended. The orifice should be protected against moisture and particulate matter with a membrane filter or moisture trap containing Drierite, silica gel, or glass wool. The air pump must be capable of maintaining a pressure differential of at least 0.6–0.7 atmospheres across the critical orifice. Alternatively, a needle valve could be used with the pump to adjust the flow through the impingers. A flowmeter is then recommended to monitor the flow. The needle valve-flowmeter combination should be protected against moisture and particulate matter with a membrane filter or moisture trap.

2.7 Thermometer. Accurate to ±1°C.

2.8 Barometer. Accurate to ±2 torr.

2.9 Volumetric flasks (Class A). 25, 100, 200, 500, 1000-ml.

2.10 Pipets (Class A). 1, 5, 10, 15, 20, and 25-ml volumetric; 1-ml or 10-ml graduated.

2.11 Spectrometer. Capable of measuring absorbance at 352 nm with an absolute accuracy of ±1% and linear response over the range of 0–1.0 absorbance units. The photometric accuracy may be checked using optical glass filters which have certified absorbance values at specified wavelengths. Matched 1-cm or 2-cm cells should be used for all absorbance determinations.

3. Reagents.

3.1 Zero air. The zero air must be free of contaminants which will cause a detectable response of the O_3 analyzer or which might react with 1% BAKI. Air meeting this requirement may be obtained by: (1) passing it through silica gel for drying; (2) treating it with O_3 to convert any nitric oxide (NO) to nitrogen dioxide (NO_2); (3) passing it through activated charcoal (6–14 mesh) and molecular sieve (6–16 mesh, type 4A) to remove any NO_2, hydrocarbons, and traces of water vapor; and (4) passing it through a 2-micron filter to remove any particulate matter.

3.2 Boric acid (H_3BO_3), ACS reagent grade.

3.3 Potassium iodide (KI), ACS reagent grade.

3.4 Hydrogfen peroxide (H_2O_2), ACS reagent grade, 3% or 30%.

3.5 Potassium iodate (KIO_3), ACS reagent grade certified 0.1N.

3.6 Sulfuric acid (H_2SO_4), ACS reagent grade, 95% to 98%.

3.7 Distilled water. Used for preparation of all reagents.

3.8 Absorbing reagent. Dissolve 6.2 g of boric acid (H_3BO_3) in approximately 750 ml of distilled water in an amber 1000-ml volumetric flask. The flask may be heated gently to speed dissolution of the H_3BO_3, but the solution must then be cooled to room temperature or below before proceeding with the reagent preparation. [While the H_3BO_3 solution is cooling, prepare the hydrogen peroxide (H_2O_2) solution according to the directions in 3.9.] When the H_3BO_3 solution has cooled, add 10 g of potassium iodide (KI) to the H_3BO_3 solution and dissolve. Add 1 ml of 0.0021% H_2O_2 solution (see 3.9) and mix thoroughly. Within 5 minutes after adding the peroxide, dilute to volume with distilled water, mix, and determine the absorbance of this BAKI solution at 352 nm against distilled water as the reference. The pH of the BAKI solution should be 5.1±0.2.

Set the absorbing solution aside for 2 hours and then redetermine the absorbance at 352 nm against distilled water as the reference. If the resultant absorbance from this second determination is at least 0.008 absorbance units/cm greater than the first determination, the absorbing reagent is ready for use. If no increase or an increase of less than 0.008 absorbance units/cm is observed, the KI reagent probably contains an excessive amount of a reducing contaminant and *must be discarded.* In this event, prepare fresh absorbing reagent using a different numbered lot of KI. If unacceptable absorbing reagent results from different lots of KI, test the possibility of contamination in the H_3BO_3 by using a different numbered lot of H_3BO_3.

3.9 Hydrogen peroxide solution 0.0021%. Using a graduated pipet, add 0.7 ml of 30% or 7.0 ml of 3% hydrogen peroxide (H_2O_2) to approximately 200 ml of distilled water in a 500-ml volumetric flask, dilute to volume with distilled water and mix thoroughly. To prepare the 0.0021% solution, pipet 5 ml of the above solution into 50 ml of distilled water in a 100-ml volumetric flask, dilute to volume with distilled water, and mix thoroughly. This 0.0021% H_2O_2 solution must be prepared fresh each time a fresh batch of absorbing reagent is prepared. Therefore, the remaining contents of both volumetric flasks should be discarded after treatment of the BAKI absorbing reagent (see 3.8).

3.10 Standard potassium iodate solution (0.1N). Use a commercial standard solution of potassium iodate (KIO_3) having a certified normality.

3.11 Sulfuric acid (1N). Dilute 28 ml of concentrated (95–98%) sulfuric acid (H_2SO_4) to volume in a 1000-ml volumetric flask.

4. Procedure.

4.1 Assemble an ozone calibration system such as shown in Figure 1.

4.2 Assemble the KI sampling train such as shown in Figure 2. All connections between the various components must be leak tight and may be made using grease-free ball joint fittings, heat-shrinkable Teflon tubing, or Teflon tube fittings. The connection to the O_3 output manifold should be made using 6 mm (¼ in.) Teflon tubing not to exceed 1.5 meters in length.

4.3 Calibrate all flowmeters and critical orfices under the conditions of use against a reliable flow or volume standard such as a NBS traceable bubble flowmeter or wet-test meter. Correct all volumetric flowrates to 25°C and 760 torr as follows:

$$F_R = F_S \times \frac{P_S - P_{H_2O}}{760} \times \frac{298}{T_S + 273}$$

where:

F_R=flowrate corrected to reference conditions (25° C and 760 torr), liter/min
F_S=flowrate at sampling conditions, liter/min
P_S=barometric pressure at sampling conditions, torr
P_{H_2O}=vapor pressure of H_2 at T_S, torr (For wet volume standard. For a dry standard, P_{H_2O}=O)
T_S=temperature at sampling conditions, °C

4.4 KI calibration curve.

4.4.1 Prepare iodine standards, fresh when needed, as follows:

A. Accurately pipet 10 ml of 0.1N standard potassium iodate (KIO_3) solution into a 100-ml volumetric flask containing approximately 50 ml of distilled water. Add 1 g of potassium iodide (KI) and 5 ml of 1N sulfuric acid (H_2SO_4), dilute to volume with distilled water, and mix thoroughly.

B. Immediately before use, pipet 10 ml of the iodine (I_2) solution prepared in step A above into a 100-ml volumetric flask and dilute to volume with absorbing reagent. Then further dilute this solution by pipetting 10 ml of it into a 200-ml volumetric flask and diluting it to volume with absorbing reagent.

C. In turn, pipet 5, 10, 15, 20, and 25 ml aliquots of the final I_2 solution prepared in step B above into a series of 25-ml volumetric flasks. Dilute each to volume with absorbing reagent and mix thoroughly. To prevent I_2 losses by volatilization, the flasks should remain stoppered until absorbance measurements are made. Absorbance measurements (see 4.4.2) should be taken within 20 minutes after preparation of the I_2 standards.

4.4.2 Determine the absorbance of each I_2 standard at 352 nm. Also measure the absorbance of a sample of unexposed absorbing reagent. Determine the net absorbance of each I_2 standard as:

$$\text{net absorbance} = \left(\begin{array}{c}\text{sample}\\ \text{absorbance}\end{array}\right) - \left(\begin{array}{c}\text{unexposed}\\ \text{reagent}\\ \text{absorbance}\end{array}\right)$$

4.4.3 For each I_2 standard, calculate the net absorbance/cm as:

$$\text{net absorbance/cm} = \frac{\text{net absorbance}}{b}$$

where:

b=spectrophotometer cell path length, cm

4.4.4 For each I_2 standard, calculate the I_2 concentration in mole/liter as:

$$[I_2]_i = N_{KIO_3} \times \frac{1 \text{ equivalent } I_2}{1 \text{ equivalent } KIO_3} \times \frac{1 \text{ mole } I_2}{2 \text{ equivalent } I_2} \times \frac{10}{100} \times \frac{10}{100} \times \frac{10}{200} \times \frac{V_i}{25}$$

$$[I_2]_i = N_{KIO_3} \times V_i \times 10^{-5}$$

where:

$[I_2]_i$=concentration of each I_2 standard, mole I_2/liter

N_{KIO_3}=normality of KIO_3 (from 3.10), equivalent liter

V_i=volume of I_2 solution (from step 4.4.1.C)=5, 10, 15, 20, or 25 ml.

4.4.5 Plot net absorbance/cm (y-axis) versus the mole I_2/liter (x-axis) for each I_2 standard and draw the KI calibration curve. Calculate the slope of the curve in liter $mole^{-1}$ cm^{-1} and record as S_c. The value of the slope should be [26,000±780. If the slope is not within this range, and the photometric accuracy of the spectrophotometer meets the specifications given in 2.11, repeat the procedure using freshly prepared I_2 standards. If the slope is still not within the specified range, repeat the procedure using a different lot of certified 0.1N KIO_3 to prepare the I_2 standards.

4.5 Calibration of the ozone generator.

4.5.1 Adjust the air flow through the O_3 generator to the desired flowrate and record as F_o. At all times the air flow through the generator must be greater than the total flow required by the sampling systems, to assure exhaust flow at the vent.

4.5.2 With the O_3 generator off, flush the system with zero air for at least 15 minutes to remove residual O_3. Pipet 10 ml of absorbing reagent into each of 2 impingers and connect them into the sampling train as shown in Figure 2. Draw air from the output manifold of the O_3 calibration system through the sampling train at 0.4-0.6 liter/min for 10 minutes. Immediately transfer the exposed solutions to clean spectrophotometer cells. Determine the net absorbance (sample absorbance-unexposed reagent absorbance) of each solution at 352 nm within three minutes. Add the net absorbances of the two solutions to obtain the total net absorbance. Calculate the indicated O_3 concentration (system blank) as equivalent O_3 concentration according to 4.5.4. If the system blank is greater than 0.005 ppm O_3, continue flushing the O_3 generation system for an additional 30 minutes and redetermine the system blank. If the system blank is still greater than 0.005 ppm O_3, the zero air probably contains traces of an oxidizing contaminant, and the activated charcoal and molecular sieve (see 3.1) should be replaced.

4.5.3 Adjust the O_3 generator to generate an O_3 concentration in the range of interest and allow the system to equilibrate for about 15 minutes. The uncalibrated O_3 analyzer to be calibrated can conveniently be used to indicate the stability of the O_3 generator output. When the O_3 generator output has stabilized, pipet 10 ml of absorbing reagent into each impinger. Draw O_3 from the output manifold of the O_3 calibration system through the sampling train at 0.4-0.6 liter/min. Use a sample time of between 10 and 30 minutes such that a total net absorbance between 0.1 and 1.0 absorbance units is obtained. (At an O_3 concentration of 0.1 ppm and a sampling rate of 0.5 liter/min, a total net absorbance >0.1 absorbance units should be obtained if a sampling time of 20 minutes and 1-cm spectrophotometer cells are used.) Immediately after collection, transfer the exposed solutions to clean spectrophotometer cells. Determine the net absorbance (sample absorbance—unexposed reagent absorbance) of each solution at 352 nm within three minutes. Add the net absorbances of the two solutions to obtain the total net absorbance.

4.5.4 Calculation of ozone concentration.

4.5.4.1 Calculate the total volume of air sampled, corrected to reference conditions of 25°C and 760 torr as:

$$V_R = F_R \times t_S$$

where:

V_R=volume of air sampled, corrected to reference conditions, liter

F_R=sampling flowrate corrected to reference conditions, liter/min

t_s=sampling time, min

4.5.4.2 Calculate the I_2 released in moles as:

$$\text{ole } I_2 = \frac{\text{total net absorbance} \times 0.01}{S_C \times b}$$

where: total net absorbance=sum of net absorbances for the two solutions

0.01=volume of absorbing reagent in each impinger, liter

S_c=slope of KI calibration curve, liter $mole^{-1}$ cm^{-1}

b=spectrophotometer cell path length, cm

4.5.4.3 Calculate the µl of O_3 absorbed as:

$$\mu l\ O_3 = \text{mole } I_2 \times \frac{1 \text{ mole } O_3}{1 \text{ mole } I_2} \times \frac{24.47 \text{ l } O_3}{\text{mole } O_3} \times \frac{10^6\ \mu l\ O_3}{\text{l } O_3}$$

or,

$$\mu l\ O_3 = \text{mole } I_2\ 24.47 \times 10^6$$

4.5.4.4 Calculate the O_3 concentration in ppm as:

$$\text{ppm } O_3 = \frac{\mu l\ O_3}{V_R}$$

4.5.5 Repeat steps 4.5.3 and 4.5.4 at least one more time at the same O_3 generator setting. Average the two (or more) determinations and record the average along with the O_3 generator setting.

4.5.6 Adjust the O_3 generator to obtain other O_3 concentrations over the desired range. Determine each O_3 concentration using the procedure given above. Five or more O_3 concentrations are recommended. Plot the O_3 concentrations versus the corresponding O_3 generator settings and draw the O_3 generator calibration curve.

4.6 Calibration of the ozone analyzer.

4.6.1 Allow sufficient time for the O_3 analyzer to warm-up and stabilize.

4.6.2 Allow the O_3 analyzer to sample zero air until a stable response is obtained and adjust the O_3 analyzer's zero control. Offsetting the analyzer's zero adjustment to +5% of scale is recommended to facilitate observing negative zero drift. Record the stable zero air response as "Z".

4.6.3 Using the O_3 generator as calibrated above and the same F_o, generate an O_3 concentration near 80% of the desired upper range limit (URL) of the O_3 analyzer.

4.6.4 Allow the O_3 analyzer to sample this O_3 concentration until a stable response is obtained. Adjust the analyzer's span control to obtain a convenient recorder response as indicated below:

$$\text{recorder response (\% scale)} = \left(\frac{[O_3]_{OUT}}{URL} \times 100\right) + Z$$

$[O_3]_{OUT}$ = O_3 concentration at the output manifold, ppm URL = upper range limit of the O_3 analyzer, ppm, Z = recorder response with zero air, % scale.

Record the O_3 concentration and the O_3 analyzer response. If substantial adjustment of the span control is necessary, recheck the zero and span adjustments by repeating steps 4.6.2 through 4.6.4.

4.6.5 Generate several other O_3 concentrations (at least 5 others are recommended) over the scale range of the O_3 analyzer by adjusting the O_3 generator settings (preferably the same settings as used in 4.5) or by Option 1. For each O_3 concentration, allow for a stable analyzer response, then record the response and the corresponding O_3 concentration.

4.6.6 Plot the O_3 analyzer responses versus the corresponding O_3 concentrations and draw the O_3 analyzer's calibration curve or calculate the appropriate response factor.

4.6.7 *Option 1:* The various O_3 concentrations required in step 4.6.5 may be obtained by dilution of the O_3 concentration generated in 4.6.3. With this option, accurate flow measurements are required. The dynamic calibration system must be modified as shown in Figure 3 to allow for dilution air to be metered in downstream of the O_3 generator. A mixing chamber between the O_3 generator and the output manifold is also required. The flowrate through the O_3 generator (F_O) and the dilution air flowrate (F_D) are measured with a reliable flow or volume standard traceable to NBS. The highest O_3 concentration standard required (80% URL) is assayed according to the procedure in 4.5. Each O_3 concentration generated by dilution is calculated from:

$$[O_3]'_{OUT} = [O_3]_{OUT} \left(\frac{F_O}{F_O + F_D}\right)$$

where: $[O_3']^{\circ}_{OUT}$ = diluted O_3 concentration, ppm; F_O = flowrate through the O_3 generator, liter/min; F_D = diluent air flowrate, liter/min.

NOTE.—Direct calibration of the O_3 analyzer may also be accomplished by assaying the O_3 concentrations using the procedure in 4.5 while simultaneously measuring the corresponding O_3 analyzer responses as specified in 4.6.

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[6568-01-C]

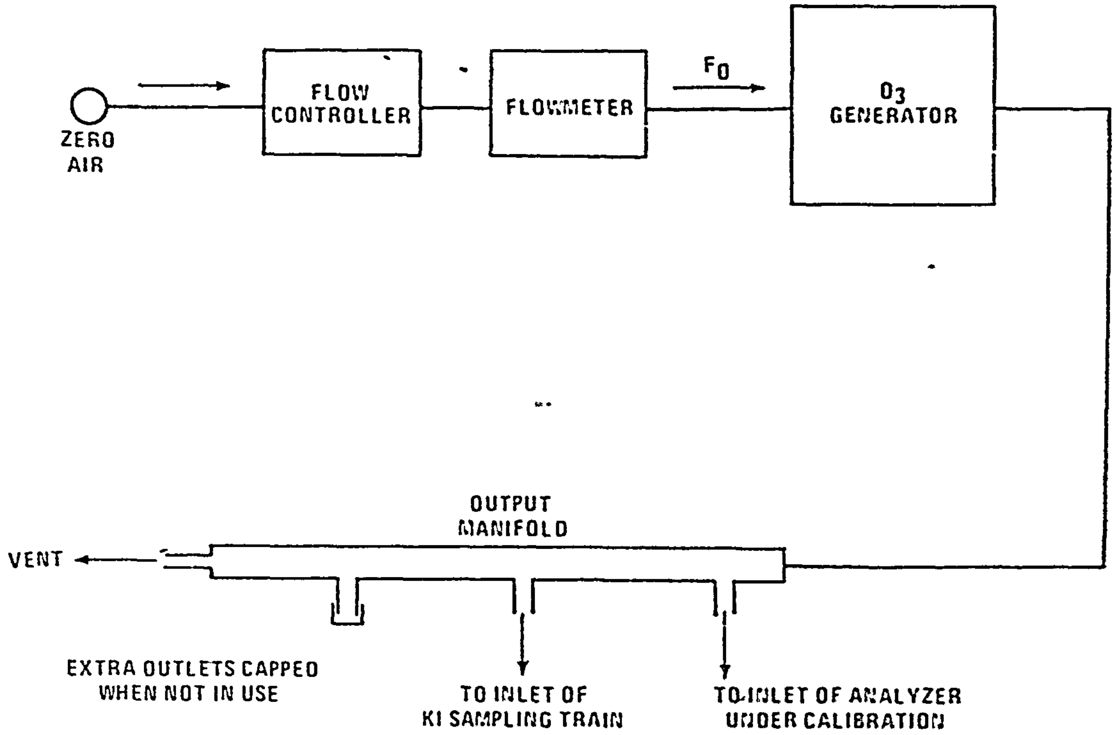

Figure 1 Schematic diagram of a typical BAKI calibration system

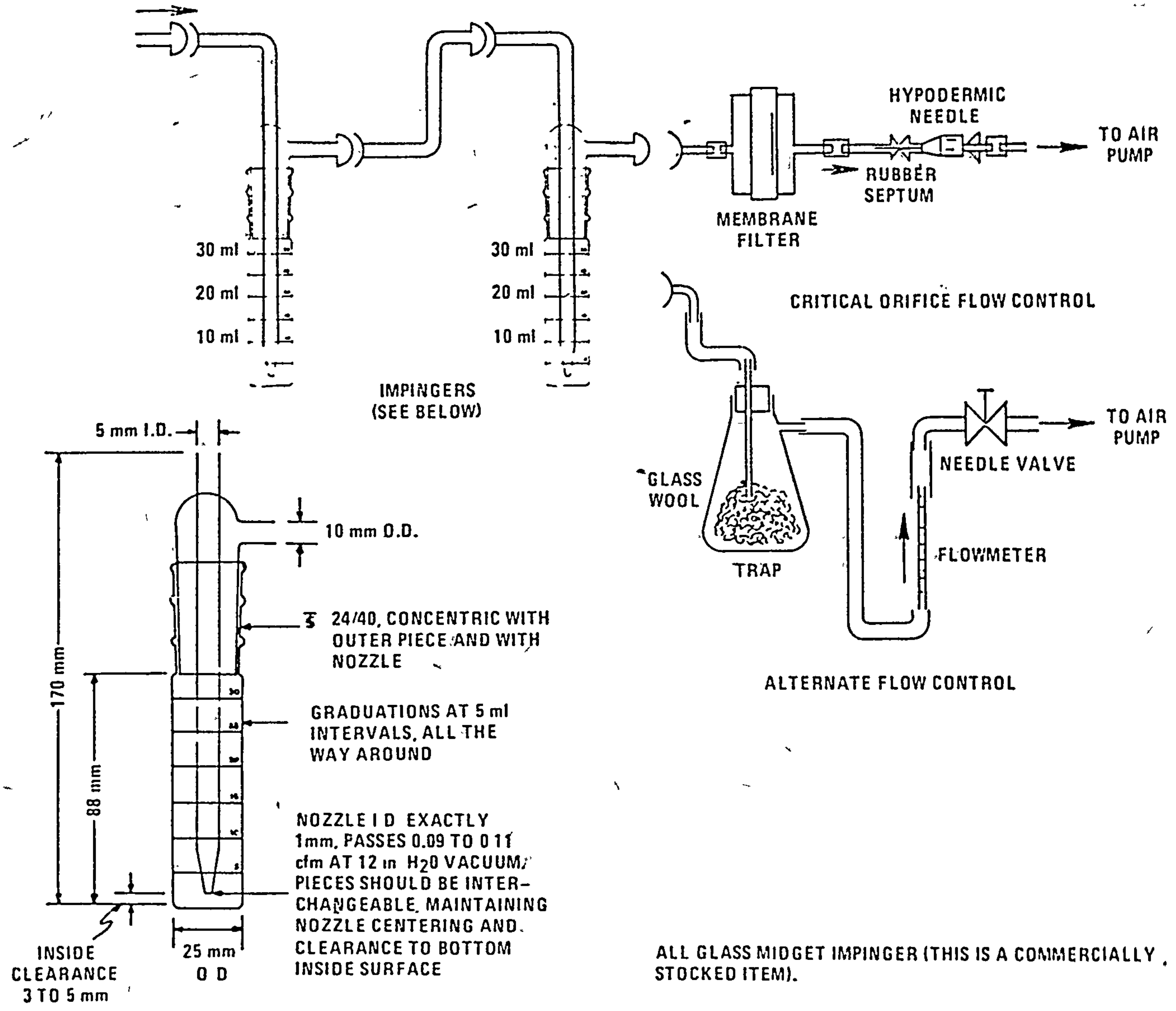

Figure 2 KI sampling train.

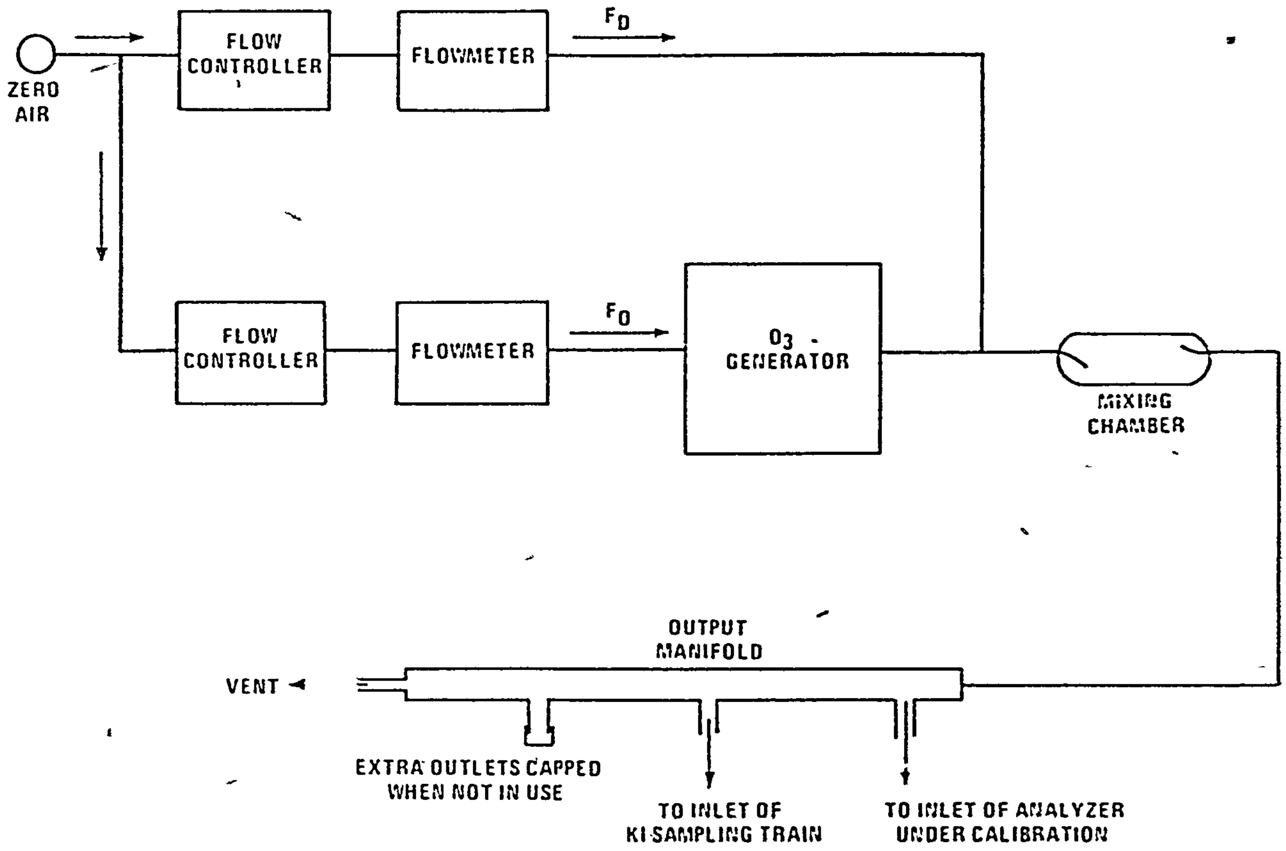

Figure 3 Schematic diagram of a typical BAKI calibration system (Option 1)

[FR Doc. 79-4057 Filed 2-7-79; 8:45 am]

[6560-01-M]

[FRL 1018-4]

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

Revisions to Implementation Procedures Related to Photochemical Oxidants (Ozone)

AGENCY: Environmental Protection Agency.

ACTION: Final rulemaking.

SUMMARY: In this action, the Administrator revises the procedures for preparation of State Implementation Plans for ozone (formerly photochemical oxidants). Throughout 40 CFR Part 51, the terms "photochemical oxidant(s)," and "oxidant(s)" are changed to "ozone" to be consistent with EPA's redesignation of the photochemical oxidant standard as an ozone standard. The redesignation action is being taken elsewhere in this issue of the FEDERAL REGISTER.

With regard to the development of a control strategy for ozone, Appendix J to 40 CFR Part 51 is being deleted and Section 51.14 is amended, to allow States to use any of four analytical relationships for determining the hydrocarbon reductions necessary to meet the ozone standard. In addition, the control strategy requirements are being amended to require that States consider background ozone concentrations and ozone transport. EPA guidance is available to States in making such considerations.

EFFECTIVE DATE: This rulemaking is effective upon publication because the revision of the national standard to which it relates is effective immediately.

ADDRESSES: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Control Programs Development Division (MD-15), Research Triangle Park, North Carolina 27711.

FOR FURTHER INFORMATION CONTACT:

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SUPPLEMENTARY INFORMATION:

1. BACKGROUND

On June 22, 1978, at 43 FR 26985, EPA proposed certain revisions to 40 CFR Part 51 concerning the procedures for preparation of State Implementation Plans for photochemical oxidants. This proposed action was taken simultaneously with related EPA proposals in the same issue of the FEDERAL REGISTER to numerically change the primary photochemical oxidant standard, to redesignate the primary and secondary standards as ozone standards, and to change to standards with a statistical form rather than a deterministic form (43 FR 26962); and to replace the existing calibration procedure for the ozone reference methods (43 FR 26971).

A total of four public hearings were held during July and August to receive comments on all the actions being taken relative to photochemical oxidants (ozone). In addition, written comments were received through October 16. EPA received comments on the proposed revisions to the implementation requirements from 27 commenters, including 12 representatives from industry, 10 from State and local governmental agencies, and 5 from citizens' organizations and private citizens.

2. SUMMARY OF COMMENTS AND RESPONSES

The following discussion summarizes the comments received on the proposal to amend 40 CFR Part 51. In some cases, similar comments are considered together in order to prepare a common response where appropriate. Where an interested person wishes to identify individual comments, a summary of all comments received, including those comments pertaining to the other related actions, and EPA's responses is available for public inspection in Docket No. OAQPS-78-8 on file in EPA's Central Docket Section, Room 2903-B, 401 M Street, S.W., Washington, D.C. 20460.

2.1 CONTROL STRATEGY

Two regulatory changes are being made with regard to the development of control strategies for ozone. First, Appendix J is being replaced by four analytical techniques. States must use one of the four techniques to determine the amount of hydrocarbon reductions necessary to demonstrate attainment of the national ozone standard. The four techniques include: (1) Photochemical dispersion models, (2) Empirical Kinetics Modeling Approach (EKMA), (3) Empirical and Statistical Models, and (4) Proportional Rollback. EPA received several comments related to these analytical techniques. These comments and EPA's responses are presented in this section.

The second change provides that States must consider background ozone concentrations and ozone transported into an area in the development of their control strategies. Previously, States were allowed to assume that there were no background ozone concentrations. The consideration of ozone background and transport may significantly affect the calculated control requirements under certain circumstances; in some cases, however, the net impact on control requirements is relatively insignificant. A discussion of these effects and procedures for taking background and transport into account is provided in the EPA document entitled *Uses, Limitations and Technical Basis of Procedures for Quantifying Relationships Between Photochemical Oxidants and Precursors* (EPA-450/2-77-021a). EPA did not receive any comments expressing opposition to this particular change; however, a number of comments were made concerning the contribution of both natural background and ozone transport to ambient ozone concentrations. Comments concerning transport are handled in this section. Some of the comments concerning natural background levels are discussed in the preamble to the 40 CFR Part 50 notice promulgating the new ozone standard which appears elsewhere in this issue of the FEDERAL REGISTER. Other comments on natural background are contained in the docket (No. OAQPS-78-8) containing information used by EPA in revising the ozone standard.

Several commenters criticized the analytical techniques proposed to replace Appendix J, citing various shortcomings of the techniques. Some commenters pointed to the failure of the EKMA and rollback techniques to account for temporal and spatial distributions of sources in the design of control strategies and pointed out that, since control of industrial sources will be extremely costly, the most effective models should be used in strategy development. One commenter indicated that the level of control necessary to achieve the standard could not be predicted with a satisfactory level of confidence since the various techniques produced different results. EPA acknowledges the fact that the various techniques do produce different results since different assumptions and different data bases are required for each specific model. Also, EPA agrees that control strategies should be based on the most effective models. However, effectiveness is in part determined by the cost of gathering input data and running a model. If simple models, such as rollback, indicate the need for extensive controls, EPA feels it may not be necessary to expend additional time and resources to gather the information needed to run a more sophisticated model which would reach the same general conclusion. A sophisticated model, i.e., a photochemical dispersion model, would appear to be most warranted in cases where there is some doubt whether extensive controls are needed to attain the standard. EPA requires that States attempting to demonstrate attainment and maintenance of the revised ozone standard by 1982 without adopting reasonably available control technology (RACT) regulations for large hydrocarbon sources must employ photochemical dispersion modeling. The use of other less rigorous analytical techniques are only acceptable in areas where RACT measures are also scheduled for implementation. Where States are unable to demonstrate attainment by 1982, EPA believes any of the models are useful for indicating the magnitude of the ozone problem and for identifying the need for major control programs to be implemented over the next several years. As these control programs are implemented and the State moves closer to attainment, it is likely that sufficient information will be acquired to use dispersion models to adjust the control strategy. Additionally, it should be noted that the city-specific version of EKMA can account, to a limited extent, for temporal and spatial distribution of sources.*(1)*

Another commenter stated that the annual emission inventory may not be readily adaptable to the models and to refine the inventory into hourly segments may be very costly, time-consuming, and inaccurate. In response, EPA points out that of the techniques specified, only photochemical dispersion models require a detailed emission inventory to arrive at their predictions (with the exception of the more sophisticated city-specific version of EKMA which can consider emission data). The other techniques primarily utilize ambient air quality data. At the same time, EPA recognizes the importance of an accurate emission inventory in translating the requirements forecast by these simple models into actual control programs. For example, suppose EKMA predicts that a 70 percent control requirement is needed to meet the standard. If the emission inventory only includes 50 percent of the emissions, a 70 percent reduction in the inventory would only result in a 35 percent reduction in actual emissions. Photochemical dispersion models, on the other hand, do require explicit information concerning hourly emissions. It would obviously be impractical to make hourly measurements for every source. However, hourly rates can be estimated by superimposing observed diurnal emission patterns on annual average emissions. Such patterns have been observed in several cities so that it would be possible to utilize annual emissions data.

Several persons commented that there is an inadequate understanding of the relationship between hydrocarbons and ozone, and that controlling hydrocarbon emissions may or may not be effective in reducing maximum ozone concentrations. This particular issue was addressed in a recent published report for the Manufacturing Chemists Association (MCA)*(2)* which noted a lack of any clear downward trend in Houston's ozone levels despite control measures to reduce hydrocarbons. This report concluded that existing ambient air quality data do not necessarily support the hypothesis that reducing hydrocarbon emissions reduces ambient ozone levels. At least two difficulties exist which prevent straightforward interpretation of the study's findings. First, the period of record was relatively short (two to three years of data) and no attempt has been made to normalize the trends for meteorological differences. It is generally believed by EPA that at least a five year period of record may be needed to discern a trend in air quality attributable to changes in emissions. A recent review of ozone trend data conducted for EPA in areas having long periods of records suggests that periods as long as eight years may be required. (*3*) Thus, while efforts are underway within EPA to develop procedures for "normalizing" trends for differing meteorology during short periods of record, at the present time trend analyses are useful in only a limited number of areas. The second difficulty in using the conclusions drawn from the study is that it appears as though some of the controls may have been initiated prior to any substantial air quality measurement programs.

EPA believes that convincing evidence exists to say that reducing hydrocarbons will reduce ambient concentrations of ozone. This position rests primarily upon experimental and theoretical studies *(4-15)* which have clearly established a physical cause-effect relationship between organic pollutants and ozone in the presence of oxides of nitrogen. Smog chamber studies have shown that maximum ozone concentrations are particularly sensitive to hydrocarbon controls when the ratio of non-methane hydrocarbons (NMHC) to nitrogen oxides (NO_x) is lower than 15-20:1. In fact, the lower the ratio the more effective the hydrocarbon strategy is likely to be. Examination of available NMHC and NO_x data suggests that most U.S. cities experience ratios in the order of 6-12:1. Also, there is a limited number of areas having ambient air quality data and emission estimates over sufficiently long periods of record that tends to confirm the theory of smog formation.*(3, 16-19)*

Two commenters indicated that a consequence of relaxing the standard could be the change of some urban areas from nonattainment to attainment status, thus, permitting greater hydrocarbon emissions than allowed by their former status. In one case the commenter argued that prior to revising the standard EPA should ascertain that existing downwind violations would not be further aggravated. The other commenter opposed the revision because, when coupled with current EPA control strategy policy, more of the burden of control would be shifted to the States where ozone is measured and away from States where emissions originate. EPA does not believe that consideration of such arguments is appropriate in setting the national primary ambient air quality standard. The Clean Air Act requires that primary standards be based solely upon effects on public health. However, the consequences indicated by the commenters are appropriate for consideration in the formulation of policy and guidance to assist States in developing a control strategy to meet the standards. EPA does not believe that either concern is warranted for areas that could be classified as attainment based on the new ozone standard. Two basic reasons exist for this EPA position: first, the potential increase in the transported levels of ozone, which may occur as a result of the greater emissions permitted by the new standard, will be offset by the equally increased allowable level of ozone in the downwind areas. Second, it should be noted that future levels of ozone being transported from attainment areas will tend to be reduced as a result of the Federal Motor Vehicle Control Program which requires reductions in the emissions of hydrocarbons and nitrogen oxides from new motor vehicles, and control requirements applicable to new stationary sources which will, in some instances, replace existing sources having fewer, less effective controls.

EPA is concerned, however, that the transport of ozone may be a problem when it originates in areas for which insufficient monitoring data preclude classifying the area as either attainment or nonattainment. EPA is now taking steps to identify areas which are currently unclassified but which have high potential for exceeding the national ozone standard. Within such areas, States will be urged to require controls on existing large stationary sources. If controls are not subsequently adopted, the States will be required to monitor for ozone, whereupon, the area in question will be classified nonattainment if violations are identified. These areas would then be subject to the requirements to control hydrocarbon emissions from existing stationary sources as in other nonattainment areas. EPA believes that the present policy focuses the limited resources of air pollution control agencies and industry on the areas (i.e., nonattainment areas) where the controls will be most effective.

One commenter suggested that the chemical diethylhydroxylamine (DEHA) be dispersed in the atmosphere to scavenge free radicals as an effective means of controlling ambient concentrations of photochemical oxidants. The use of various free radical scavenger compounds has been suggested in the past as a means of reducing pollutant concentrations; however, no compound has yet been demonstrated to be completely acceptable. Before this approach to controlling air pollution can be seriously considered, comprehensive studies must show not only that the chemical employed is effective in laboratory studies, but also that the results can be extrapolated to actual ambient atmospheres. Such concerns as how, when and where to introduce the chemical to the atmosphere constitute problems whose solutions can be extremely difficult to derive. Futhermore, thorough consideration must be given to the potential hazards of exposing a population to a smog-inhibiting chemical or to any of its reaction products. One of the earliest suggestions for using DEHA came as a result of its ability to inhibit conversion of NO to NO_2. Consequently, various tests of DEHA's smog-inhibiting ability have been performed over the past several years. Recently, irradiation of mixtures of NO_x, HC and DEHA was carried out in a large smog chamber at EPA's Research Triangle Park, North Carolina, facility. Test results indicated that while the initial effect of adding DEHA is an immediate suppression of ozone formation, consumption of the chemical ultimately causes increased formation of ozone and ozone producing chemicals. The studies pointed to possible adverse impacts on rural areas downwind from the urban center as well. Further problems raised by the studies included, among others, the danger of exceeding the odor threshold of DEHA at certain "effective" atmospheric doses, and population exposure to an unknown NO_x product being formed by the DEHA reactions. (*20*) Obviously, EPA cannot at this time accept or encourage the use of DEHA as an effective control strategy for ozone. Instead, EPA believes that direct control of precursor emissions will result in greater and more certain improvements in air quality.

Several commenters claimed that the ozone problem is an urban problem and EPA requirements for control strategies should concentrate on the urban area while paying special attention to the present levels of NO_x and the NMHC/NO_x ratio. EPA agrees that the ozone attainment problem is primarily an urban problem. Consequently, the most stringent requirements are imposed in the urbanized nonattainment areas with a population greater than 200,000. Low NMHC/NO_x ratios primarily occur in the urbanized areas thus the required controls would be effective in controlling ozone levels. However, EPA does not feel it is appropriate to completely ignore hydrocarbon emissions outside the urbanized nonattainment areas because these emissions may contribute to the overall ozone nonattainment problem, particularly during adverse meteorological conditions. EPA therefore believes it is justified in requiring that large hydrocarbon sources (more than 100 ton/year potential emissions) in rural nonattainment areas implement reasonably available control techniques (RACT) to reduce their organic emissions.

One commenter claimed that EPA failed to issue timely guidance on control techniques as required by the Clean Air Act and as needed by States in revising their implementation plans. The commenter's argument is based on Section 108(b)(1) of the Clean Air Act which requires control technique information to be issued simultaneously with the issuance of health and welfare related air quality criteria. EPA did issue the control technique information required by the Act in a document entitled "Control Techniques for Volatile Organic Emissions from Stationary Sources" (EPA-450/2-78-022, May, 1978). However, this was not the information which EPA intended States to use to develop and enforce regulations for implementation plans. In addition to the document described above, EPA has published a series of Control Technique Guidelines (CTGs) which define reasonably available control technology (RACT) for stationary sources of hydrocarbons. These CTGs are specifically designed to assist States and local agencies in the development of air pollution control regulations for volatile organic emissions. The ozone SIPs due on January 1, 1979 are to reflect the application of RACT to the stationary sources for which EPA has published CTGs by January 1978. Additional CTGs are planned for future publication such that States will be required to adopt and submit additional RACT regulations on an annual basis beginning in January 1980, for those CTGs that have been published by January of the preceding year.

One commenter inquired as to why the proposal did not retain the original statement contained in Section 51.14(c)(4) which allowed States to assume that the hydrocarbon emission reductions necessary to attain the ozone standard would also be adequate to attain the national hydrocarbon standard. EPA's response is that this statement was unintentionally omitted from the June 22 proposal, and this omission is being corrected in today's action. Previously, statements concerning the attainment of the ozone standard and the hydrocarbon standard were both contained in Section 51.14(c)(4). To take the actions described herein, EPA is deleting (and reserving) paragraph (c)(4) of Section 51.14 and establishing three new paragraphs (c)(7), (c)(8), and (c)(9). Paragraph (c)(7) is to be used to set forth the four analytical techniques for determining the amount of hydrocarbon reduction necessary to demonstrate attainment of the ozone standard; paragraph (c)(8) describes specific considerations to be made in developing the ozone control strategy; and paragraph (c)(9) addresses attainment of the hydrocarbon standard.

2.2 SUBMITTAL OF SIP REVISIONS

Several industrial and governmental agency spokesmen expressed the opinion that EPA should grant States extensions of up to nine months to correct their SIPs to be consistent with the revision of the ozone standard. EPA's response to this request is provided in detail in the preamble to the revision of the ozone standard appearing elsewhere in today's FEDERAL REGISTER. In summary, States are still expected to submit their plan revisions to EPA on January 1, 1979, as required by the Clean Air Act. These plans will most likely be based upon the old standard of 0.08 p.p.m. However, once submitted, any State is free to make the additional revisions necessary to account for the revised standard, if they so desire. Thus, the time schedule for submitting the latter revisions is to be determined by each State.

3. OTHER CHANGES FROM PROPOSAL

In reviewing the June 22 proposed rule, EPA has determined that two changes from the proposal are necessary even though no comments addressing these particular matters were received. With regard to the first change, EPA originally proposed to change the terms "photochemical oxidants" and "oxidants" to "ozone" in 40 CFR Parts 51 and 52 to be consistent with the proposed redesignation of the photochemical oxidant standard to an ozone standard. EPA has decided not to proceed with the proposed nomenclature changes in Part 52 at this time. The reason for this decision is that in numerous places throughout Part 52 the terms "photochemical oxidants" and "oxidants" are used either as part of the title of a State Implementation Plan or to denote use of the terms within the plan itself. EPA therefore, feels that it would be proper to wait until States made the appropriate nomenclature changes in their plans prior to enacting any changes to Part 52.

The second change concerns EPA's proposal to allow States to use photochemical *grid* models as one of four analytical techniques for determining the needed hydrocarbon emission reductions. The intended terminology for such models should have been photochemical *dispersion* models. There are two major types of dispersion models—grid (or Eulerian) and Lagrangian. EPA intends to allow either type model to be used where appropriate. Thus, the more inclusive terminology (i.e., photochemical dispersion models) will appear in Section 51.14(c)(7)(i).

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Dated: January 26, 1979.

DOUGLAS M. COSTLE,
Administrator.

The *Code of Federal Regulations*, Title 40, Chapter I, Part 51, is amended as follows:

1. Wherever the terms "photochemical oxidant(s)" or "oxidant(s)" appear in Part 51, they are changed to read "ozone."

2. Appendix J is deleted and reserved.

3. Section 51.14(c) is amended by deleting and reserving paragraph (4) and by adding new paragraphs (7), (8) and (9) as follows:

§ 51.14 Control strategy: Carbon monoxide, hydrocarbons, ozone, and nitrogen dioxide.

* * * * *

(c) * * *

(4) [Reserved]

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(7) In selecting an appropriate model to determine the amount of hydrocarbon reductions necessary to demonstrate attainment of the ozone standard, one of the following techniques must be applied:

(i) Photochemical dispersion models—These models are based on the most accurate available physical and chemical principles underlying the formation of ozone.

(ii) Empirical Kinetics Modeling Approach (EKMA)—This model represents a compromise between rigorous treatment of chemical and physical principles underlying ozone formation and dispersion and the extensive data requirement that would be necessitated by such an approach.

(iii) Empirical and statistical models—These models reflect observed relationships between ozone and other variables.

(iv) Proportional rollback—This model assumes a linear relationship between hydrocarbon emissions and ambient concentrations of ozone.

(8) In developing an ozone control strategy for a particular area, background ozone concentrations and ozone transported into an area must be considered. States may assume that the ozone standard will be attained in upwind areas.

(9) The degree of total hydrocarbon emission reduction necessary for attainment of the national standard for ozone will also be adequate for attainment of the national standard for hydrocarbons.

AUTHORITY: Sections 110 and 301(a), Clean Air Act, as amended (42 U.S.C. 7410, 7601).

[FR Doc. 79-4058 Filed 2-7-79; 8:45 am]