Authority: 5 U.S.C. 301 *et seq.* 25 U.S.C. 396 *et seq.*, 396a *et seq.*, 2101 *et seq.* 30 U.S.C. 181 *et seq.*, 351 *et seq.*, 1001 *et seq.*, 1701 *et seq.*; 31 U.S.C. 3716, 3720A, 9701; 43 U.S.C. 1301 *et seq.*, 1331 *et seq.*, 1801 *et seq.*

2. Paragraph (b) of § 218.40 under Subpart A, General Provisions, is revised to read as follows:

§ 218.40 Assessments for incorrect or late reports and failure to report.

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(b) An assessment of an amount not to exceed $10 may be charged for each incorrectly completed report.

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[FRDoc. 94-18573 Filed 7-29-94; 8:45 am]

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ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 50

[AD-FDL-4735-5]

National Ambient Air Quality Standards for Carbon Monoxide—Final Decision

AGENCY: U.S. Environmental Protection Agency (U.S. EPA).

ACTION: Final decision.

SUMMARY: Identical primary (health-based) and secondary (welfare-based) national ambient air quality standards (NAAQS) for carbon monoxide (CO) were promulgated in 1971 at 9 parts per million (ppm), 8-hour average, and 35 ppm, 1-hour average, neither to be exceeded more than one time per year. In 1985, the EPA announced the decision not to revise the primary CO NAAQS and at the same time to revoke the secondary CO NAAQS. In accordance with sections 108 and 109 of the Clean Air Act (Act), the EPA has reviewed and revised the criteria upon which the existing NAAQS for CO are based. Based on that review, this document announces the EPA's final decision under section 109(d)(1) that revisions of the NAAQS for CO are not appropriate at this time.

ADDRESSES: A docket containing information relating to the EPA's review of the CO NAAQS (Docket No. A-93-05) is available for public inspection in the Air and Radiation Docket and Information Center of the U.S. Environmental Protection Agency, South Conference Center, Room 4, 401 M Street, SW., Washington, DC. The docket may be inspected between 8 a.m. and 4 p.m. on weekdays, and a reasonable fee may be charged for copying. The information in the docket constitutes the complete basis for the decision announced in this notice. For availability of related information, see SUPPLEMENTARY INFORMATION.

FOR FURTHER INFORMATION CONTACT: Dr. David J. McKee, Air Quality Management Division (MD-12), U.S. Environmental Protection Agency, Research Triangle Park, NC 27711, telephone (919) 541-5288.

SUPPLEMENTARY INFORMATION:

Availability of Related Information

Certain documents are available from: U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. Available documents include: the revised criteria document, "Air Quality Criteria for Carbon Monoxide" (EPA/600/8-90-045F; NTIS # PB 93-167492, $77.00 paper copy and $27.00 microfiche), and the 1992 staff paper, "Review of the National Ambient Air Quality Standards for Carbon Monoxide: Assessment of Scientific and Technical Information-OAQPS Staff Paper" (EPA-452/R-92-004, August 1992; NTIS No. PB 93-157717, $19.50 paper copy and $9.00 microfiche). (Add $3.00 handling charge per order.) Other documents generated in connection with review of this standard (e.g., exposure analysis) are available in the EPA Docket No. A-93-05.

The contents of this document are listed in the following outline:

I. Background

A. Legislative Requirements Affecting This Decision

1. Primary and Secondary Standards

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

Section 109 (42 U.S.C. 7409) directs the Administrator to propose and promulgate "primary" and "secondary" NAAQS for pollutants identified under section 108. Section 109(b)(1) defines a primary standard as one the attainment and maintenance of which, in the judgment of the Administrator, based on the criteria and allowing an adequate "margin of safety," [is] requisite to protect the public health. A secondary standard, as defined in section 109(b)(2), must specify a level of air quality the attainment and maintenance of which, in the judgment of the Administrator, based on [the] criteria, is requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of [the] pollutant in the ambient air. Welfare effects as defined in section 302(h) [42 U.S.C. 7602(h)] include, but are not limited to, effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being.

The U.S. Court of Appeals for the District of Columbia Circuit has held that the requirement for an adequate "margin of safety" for primary standards was intended to address uncertainties associated with inconclusive scientific and technical information available at the time of standard setting. It was also intended to provide a reasonable degree of protection against hazards that research has not yet identified. [*Lead Industries Association* v. *EPA*, 647 F.2d 1130,1154 (D.C. Cir. 1980), *cert. denied*, 101 S. Ct. 621 (1980); *American Petroleum Institute* v. *Costle*, 665 F.2d 1176,1177 (D.C. Cir. 1981), *cert. denied*,

102 S. Ct. 1737 (1982)[1]. Both kinds of uncertainties are components of the risk associated with pollution at levels below those at which human health effects can be said to occur with reasonable scientific certainty. Thus, by selecting primary standards that provide an adequate "margin of safety/" the Administrator is seeking not only to prevent pollution levels that have been demonstrated to be harmful but also to prevent lower pollutant levels that she finds may pose an unacceptable risk of harm, even if the risk is not precisely identified as to nature or degree.

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

Section 109(d)(1) of the Act requires that not later than December 31, 1980, and at 5-year intervals thereafter, the Administrator shall complete a thorough review of the criteria published under section 108 and the NAAQS and shall make such revisions in such criteria and standards as may be appropriate. Section 109(d)(2) (A) and (B) requires that a scientific review committee be appointed and provides that the committee shall complete a review of the criteria and the national primary and secondary ambient air quality standards and shall recommend to the Administrator any revisions of existing criteria and standards as may be appropriate. If the EPA decides to revise an existing standard, the rulemaking procedures of section 307(d) apply.[1]

The process by which the EPA has reviewed the existing air quality criteria and standards for CO under section 109(d) is described in a later section of this notice.

2. Related Control Requirements

States are primarily responsible for ensuring attainment and maintenance of ambient air quality standards once the EPA has established them. Under title I of the Act (42 U.S.C. 7410), States are to submit, for EPA approval, State implementation plans (SIP's) that provide for the attainment and maintenance of such standards through control programs directed to sources of the pollutants involved. The States, in conjunction with the EPA, also administer the prevention of significant deterioration program (42 U.S.C. 7470-7479) and the visibility protection program (42 U.S.C. 7491-7492) for these and other air pollutants. In addition, Federal programs provide for nationwide reductions in emissions of air pollutants through the Federal motor vehicle control program under title II of the Act (42 U.S.C. 7521-7574), which involves controls for automobile, truck, bus, motorcycle, and aircraft emissions; the new source performance standards under section 111 (42 U.S.C. 7411); and the national emission standards for hazardous air pollutants under section 112 (42 U.S.C. 7412).

B. Existing Primary Standards for Carbon Monoxide

On April 30, 1971, the EPA promulgated NAAQS for CO under section 109 of the Act (36 FR 8186). Identical primary and secondary NAAQS were set at 9 ppm as an 8-hour average and 35 ppm as a 1-hour average, neither to be exceeded more than once per year. Scientific and technical bases for these NAAQS are provided in the document, "Air Quality Criteria for Carbon Monoxide" (U.S. Dept. of Health, Education and Welfare, 1970). The NAAQS promulgated in 1971 were based largely upon research by Beard and Wertheim (1967) who reported that CO exposures which produced carboxyhemoglobin (COHb) levels of 2 to 3 percent were associated with central nervous system (CNS) effects such as impaired ability to discriminate time intervals.

A revised Air Quality Criteria for Carbon Monoxide (U.S. EPA, 1979a), prepared by the Environmental Criteria and Assessment Office (ECAO), and a Staff Paper (U.S. EPA, 1979b), prepared by the Office of Air Quality Planning and Standards (OAQPS), identified several major factors pertinent to subsequent action taken on the NAAQS for CO. The Clean Air Scientific Advisory Committee (CASAC) met on June 14–15, 1979 to review drafts of these documents and provide advice on the CO standards. As discussed in a notice of proposed rulemaking (45 FR 55066) published on August 18, 1980, although the Beard and Wertheim (1967) study no longer could serve as a basis for the CO NAAQS, other studies available in 1980 provided alternative evidence of decreased time to onset of angina attack at COHb levels as low as 2.7 to 3.0 percent. This as well as other scientific evidence served as the basis for the EPA to propose: (1) Retaining the 8-hour primary standard level of 9 ppm, (2) revising the 1-hour primary standard level from 35 ppm to 25 ppm, (3) revoking the existing secondary CO NAAQS due to a lack of evidence of adverse welfare effects at or near ambient CO levels, (4) changing the form of the standard from deterministic to statistical by stating allowable exceedances as expected values rather than as explicit values, and (5) adopting a daily interpretation for exceedances of the CO NAAQS so exceedances would be determined on the basis of days on which the 8- or 1-hour average concentrations were above the standard levels.

On June 18, 1982, the EPA announced (47 FR 26407) that a second public comment period was necessary to open discussion on several important issues and additional analyses. These issues included: (1) The role of the Aronow (1981) study in assessing CO effects; (2) consideration of a multiple exceedance 8-hour standard for CO; (3) technical adequacy of the revised draft sensitivity analysis (Biller and Richmond, 1982) on the Coburn, Forster, and Kane model predictions of COHb levels; and (4) technical adequacy of the revised exposure analysis (Johnson and Paul, 1983). The CASAC met on July 6, 1982 to discuss these issues and provide advice, a summary of which was sent to the Administrator on August 31, 1982 (Friedlander, 1982).

The 1980 proposal (45 FR 55066) was based in large part on studies by Dr. Wilbert Aronow (Aronow, 1978; Aronow, et al., 1972, 1973, 1974a, 1974b, 1977; Aronow and Isbell, 1973; Aronow and Cassidy, 1975), which provided the CASAC and the EPA staff

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[1] The EPA has also chosen to follow rulemaking procedures in several NAAQS reviews that did not involve revision of existing standards. However, the EPA interprets section 307(d) as not requiring such procedures where the Administrator decides to retain an existing standard without change; i.e., to maintain the status quo. Although such a decision is subject to judicial review as a final action under section 307(b), neither the Act nor its legislative history evidences any intent to require rulemaking where the Administrator has not concluded that revision of an existing NAAQS is appropriate. The Agency's conclusion that rulemaking procedures are not required to retain an existing NAAQS without revision is not affected by the Court's brief reference to the use of rulemaking procedures in *Environmental Defense Fund* v. *Thomas*, 870 F.2d 892, 900 (2d Cir.), *cert. denied*, 110 S.Ct. 537 (1989). As a practical matter, even without the use of rulemaking procedures, the process by which the EPA reviews existing criteria and standards involves substantia) opportunities for public and expert comment on both its assessment of relevant scientific and technical data and its proposed use of the data for decision making purposes.

with a basis for concluding that COHb levels of 2.7–3.0 percent posed a health risk of concern in individuals with angina and other types of cardiovascular disease. A subsequent disclosure in March 1983 by the Food and Drug Administration (FDA) concerning work conducted for the FDA by Dr. Aronow caused the EPA to question the scientific credibility of Dr. Aronow's research on CO. As a result, the EPA decided it would be prudent to conduct an independent review of his CO research prior to making a decision on the CO standards. A committee of experts was convened and chaired by Dr. Steven Horvath (University of California, Santa Barbara). Following meetings with Dr. Aronow and examination of limited data and records available from his CO studies, the committee concluded in its report (Horvath et al., 1983) that the EPA should not rely on Dr. Aronow's studies for a decision on levels of the CO NAAQS due to problems regarding data collection/analysis.

As a result of this finding, the ECAO prepared a draft Addendum to the 1979 Air Quality Criteria for Carbon Monoxide. Concurrently, the OAQPS prepared a draft Review of the NAAQS for Carbon Monoxide: Reassessment of Scientific and Technical Information. These documents were prepared to reevaluate the scientific and technical evidence on health effects of CO at or near ambient levels in consideration of the reduced usefulness of the Aronow studies. Both documents were reviewed by the CASAC at a public meeting on September 25, 1983. The CASAC sent a closure letter to the Administrator on May 17, 1984, which concluded that the draft Addendum and the draft Staff Paper Reassessment represented scientifically-balanced and defensible summaries of health effects literature for CO. On August 9, 1984, the EPA announced (49 FR 31923) availability of the final Addendum (1984b) and final Staff Reassessment (1984a), both of which had been revised to reflect the CASAC's and public comments. In the same notice, the EPA reviewed the basis for the 1980 proposal to revise the CO standards and solicited additional public comment. In a subsequent Federal Register notice (50 FR 37484) published on September 13, 1985, the EPA announced its final decision not to revise the existing primary standards and to revoke the secondary standards for CO. In doing so, the Administrator determined that the existing 1-hour and 8-hour primary NAAQS provided adequate protection from exposure to ambient CO.

C. Review of Air Quality Criteria and Standards for Carbon Monoxide; Development of the Staff Paper

On July 22, 1987, the ECAO published in the Federal Register (52 FR 27580) a call for information to assist in the development of a draft revised Air Quality Criteria for Carbon Monoxide (Criteria Document). Notice of availability of the external review draft Criteria Document was published in the Federal Register (55 FR 14858) on April 19, 1990. This draft Criteria Document included discussion of several new studies of effects of CO on angina patients, which had been initiated in light of the controversy discussed above. The CASAC reviewed the draft Criteria Document at a public meeting held on April 30, 1991. The EPA placed a transcript of the CASAC meeting in the docket (ECAO-CD-86-073). The EPA carefully considered comments received from the public and the CASAC members in preparing the final Criteria Document (U.S. EPA, 1991). On July 17, 1991, the CASAC sent to the Administrator a "closure letter" (McClellan, 1991) outlining key issues and recommendations ahd indicating that the document provides a scientifically-balanced and defensible summary of current knowledge of the effects of this pollutant and provides an adequate basis for the EPA to make a decision as to the appropriate primary NAAQS for CO.

Immediately following the CASAC meeting of April 30, 1991, the OAQPS began development of the revised draft Staff Paper. This document was released for public review in February 1992. The CASAC held a public meeting on March 5, 1992 to review the draft revised Staff Paper. A copy of the transcript of this meeting has been placed in the docket (A–93–05). Major issues discussed at the meeting included: interpretation of new scientific information, the definition of adverse health effects associated with CO exposure, populations at risk, COHb levels of concern, and estimates of population exposure. In response to comments made by the public and the CASAC members, minor revisions to the Staff Paper were made and briefly reviewed at a public meeting of the CASAC held on April 28, 1992 prior to preparation of the final Staff Paper (U.S. EPA, 1992). The CASAC came to closure on its review of the Staff Paper in a letter to the Administrator dated August 11, 1992. In that "closure letter" (McClellan, 1992) the CASAC states that "this document is consistent with all aspects of the scientific evidence presented in the criteria document for carbon monoxide. It has organized the relevant information in a logical fashion and the Committee believes that it provides a scientifically adequate basis for regulatory decisions on carbon monoxide. The staff paper concludes, and the CASAC concurs, that a standard of the present form and with a numerical value similar to that of the present standard would be supported by the present scientific data on health effects of exposure to carbon monoxide."

D. Decision Docket

On February 2, 1993, the EPA created a docket (Docket No. A–93–05) for this decision. The docket incorporated by reference a separate docket established in 1986 for criteria document revision (Docket No. ECAO-CD-86-073).

II. Scientific Basis for This Regulatory Decision

A. Measuring and Assessing COHb Levels

As concluded in the Staff Paper (U.S. EPA, 1992, p. 10), blood COHb level is not only the best indicator of CO exposure but also has been related to health effects of major concern for CO. In most CO health effects studies, the co-oximeter (CO-Ox) has been used to measure COHb at levels in the range of 0 to 5 percent COHb; however, concerns have been raised regarding accuracy of the CO-Ox.

While CO-Ox measurements are very precise (i.e., replicable), research has shown that the accuracy (i.e., ability to detect the actual level) of these optical instruments is not always sufficient to use alone at levels ≤ 5 percent COHb (Allred et al., 1989a,b, 1991). As indicated in the Criteria Document (U.S. EPA, 1991, pp. 8–72 to 8–73), the results from linear regression analyses of comparisons between CO-Ox instruments and various reference instruments [involving gas chromatography (GC)] show a fairly linear slope and a wide range of intercept values, thus suggesting good precision but poor accuracy for the CO-Ox. In the only health effects study that used both CO-Ox and GC methods to measure COHb levels in subjects with heart disease, researchers found that the spread of COHb values was much greater for the CO-Ox values than for the GC values (Allred et al., 1989a,b, 1991).

In order for optical instruments such as CO-Ox to be used to measure COHb levels accurately at low levels, they must be calibrated routinely with an alternative method (U.S. EPA, 1991, p. 8–64). When properly calibrated, CO-Ox instruments provide useful

information on mean COHb values; however, variation in individual oxyhemoglobin (OjHb) levels appears to influence COHb readings (Allred et al., 1989a,b) and, as noted above, CO-Ox instruments also give a broader range of COHb values when compared to GC measurements on the same samples (Allred et al., 1989a,b, 1991). Although the CASAC identified the GC as the method of choice (McClellan, 1992), the fact that most ofithe health effects literature for CO relies on CO-Ox measurements led to the decision that CO-Qx data would be used in establishing levels of concern.

B. Health Effects Associated With Carbon Monoxide

Health effects associated with exposure to CO include cardiovascular system effects, CNS effects, and developmental toxicity effects, as well as effects of combined exposure to CO and other pollutants, drugs, and environmental factors. Cardiovascular effects of CO are directly related to a reduced oxygen (O_2) content of the blood caused by combination of CO with hemoglobin (Hb) to form COHb and resulting in tissue hypoxia. Most healthy individuals have mechanisms (e.g., increased blood flow, blood vessel dilation) which compensate for this reduction in tissue O_2 levels, although the effect of reduced maximal exercise capacity has been reported in healthy persons even at low COHb levels. Compensatory mechanisms are less effective in elderly people, pregnant women, small children, and in certain people with anemia or pulmonary and cardiovascular diseases, thereby increasing their susceptibility to potential adverse effects of CO during exercise. Research studies considered most significant to the establishment of NAAQS for CO are summarized in Table 1 and are discussed below.

1. Mechanisms of Toxicity

The mechanism of toxicity principally associated with health effects of greatest concern from CO exposure is hypoxia induced by elevated COHb levels. The primary exchange route for CO to human tissues is through the lungs. Although CO is a naturally occurring chemical in blood being produced endogenously by normal catabolic processes, blood COHb levels do not often exceed 0.5 to 0.7 percent in normal individuals unless exogenous CO is breathed. Some individuals with high endogenous CO production can have COHb levels of 1.0 to 1.5 percent (e.g., anémies). Exogenous CO diffuses through the respiratory zone (alveoli) to the blood where it binds to Hb to form COHb. The chemical affinity of CO for Hb is 218 to 250 times greater than that of O_2 (Roughton, 1970; Wyman et al., 1982; Rodkey et al., 1969). This preferential binding of CO to Hb limits the availability of Hb for O_2 transport to tissues throughout the body. As COHb levels increase, the dissociation curve for normal human blood is shifted to the left resulting in more reduced delivery of O_2 to tissues and a greater of CO-induced hypoxia. It is this reduced O_2 delivery to heart muscle tissue which is of great concern for individuals with ischemic heart disease because their already compromised condition puts them at increased risk.

TABLE 1.—KEY HEALTH STUDIES FOR ESTABLISHING NAAQS FOR CARBON MONOXIDE

COHb content percent[a]	Health effects	References[b]
2.3–7.0	Decreased short-term maximal exercise duration in young healthy men.	Drinkwater et al. (1974), Ekblom and Huot (1972), Horvath et al. (1975), Raven et al. (1974a,b), Weiser et al. (1978).
2.9–6.9	Decreased exercise duration due to increased chest pain (angina) in patients with ischemic heart disease.	Adams et al. (1988), Allred et al. (1989a,b; 1991), Anderson et al. (1973), Kleinman et al. (1989), Sheps et al. (1987).
5.0–20.0	Decreased maximal oxygen consumption with short-term strenuous exercise in young healthy men.	Ekblom and Huot (1972), Klein et al. (1980), Pimay et al. (1971), Stewart et al. (1978), Vogel and Gleser (1972), Weiser et al. (1978).
5.0–20.0	Equivocal effects on visual perception, audition, motor and sensorimotor performance, vigilance, and other measures of neurobehavioral performance.	Benignus et al. (1977, 1987, 1990a,b), Bunnell and Horvath (1988), Christensen et al. (1977), Gliner et al. (1983), Harbin et al. (1988), Hudnell and Benignus (1989), McFarland (1970, 1973), McFarland et al. (1944), Mihevic et al. (1983), O'Donnell et al. (1971), Putz et al. (1976) Putz (1979), Roche et al. (1981), Rummo and Sartanis (1974), Seppanrien et al. (1977), Von Post-Lingen (1964), Winneke (1974).

[a] Blood COHb levels determined by optical methods.
[b] References also found in U.S. EPA (1991) and U.S. EPA (1992).

Although several other mechanisms of toxicity are discussed in the Criteria Document (U.S. EPA, 1991), these are not considered to be as well understood as COHb hypoxia. Intracellular effects of CO (U.S. EPA, 1991, pp. 9-22 to 9-31) have been associated with CO toxicity. Preferential binding of CO to myoglobin, cytochrome P-450, and cytochrome c oxidase has been studied and could lead to impairment of intracellular oxygen transport to mitochondria. However, mechanisms of toxicity associated with CO-induced inhibition of these hemoproteins at relevant CO levels are not well understood at this time and will require further research.

Based on the review and conclusions drawn in the Criteria Document (U.S. EPA, 1991), COHb levels provide the most useful estimate of exogenous CO exposures and serve as the best biomarker of CO toxicity for ambient-level exposures to CO. Thus, COHb levels are used as the indicator of health effects and to identify the lowest effects level for CO.

2. Cardiovascular Effects

The best documented cardiovascular effects of CO in patients with chronic heart disease are decreased time to onset of chest pain and ST-segment depression during exercise stress. The commonly accepted criterion of exércise-induced myocardial ischemia is 1 mm or greater ST-segment depression. The ST segment is a portion of the electrocardiogram (ECG), depression of which is an indication of insufficient O_2 supply to heart muscle tissue.

Five key studies on cardiovascular effects of CO (Allred et al., 1989a,b, 1991; Kleinman et al., 1989; Adams et al., 1988; Sheps et al., 1987; Anderson et al., 1973) have provided evidence of the potential for CO to enhance development of exercise-induced

myocardial ischemia in patients who suffer from angina pectoris. (Angina pectoris is a spasmodic, strangling sensation or heavy chest pain, often radiating to the arms, especially the left, most often due to lack of O_2 to the heart muscle and precipitated by effort or excitement.) An early study by Anderson et ah (1973) reported decreased time to onset of angina pain for COHb levels as low as 2.9 (CO-Ox), representing a 1.6 percent increase in average GOHb levels over baseline. Details of this study were reported at length in the Addendum (U.S. EPA, 1984b).

More recent controlled exposure studies of angina patients have provided substantial new evidence of decreased time to early onset of chest pain. (See discussion in U.S. EPA, 1991, pp. 10-21 to 10-35). A study which provides strong evidence of the health effects of CO is the multicenter study of Allred et al. (1989a,b, 1991). There are several reasons why this particular study is important to the CO NAAQS review: (1) Dose-response relationships are shown, (2) information on ST-segment depression of subjects is available, (3) COHb measurements were taken using both GC and CO-Ox, (4) a large number of subjects was used, and (5) it was conducted at multiple laboratories around the U.S. This study involved 63 males (41–75 years of age) with coronary artery disease living in three different U.S. cities. The objective was to assess the impact of exposure to CO on time to onset of significant ischemia during a standard treadmill test. Unusual care was taken to establish presence of coronary artery disease in all subjects prior to testing. The protocol for the study was quite similar to that used in the Aronow studies, i.e., two exercise tests were performed on the same day separated by a recovery period and a double-blind exposure period. Subjects were exposed to either clean air, 117 ppm CO, or 253 ppm CO for 50 to 70 minutes while performing symptom-limited exercise on a treadmill. Time to onset of angina and time to ST-segment depression were determined for each test following exposure to both CO levels and compared to clean air (≤2 ppm CO) exposure. After exposure to 117 ppm and 253 ppm CO, COHb levels measured before the exercise stress test were 2.4 and 4.7 percent COHb (GC) and 3.2 and 5.6 percent COHb (CO-Ox), respectively. After the stress test COHb levels were 2.0 and 3.9 percent (GC) and 2.7 and 4.7 percent (CO-Ox). Using the objective measure of time to ST-segment depression, CO exposure which produced 3.2 percent COHb (CO-Ox, pretest) resulted in a 5.1 percent ($p=0.01$) decrease in time to the ST criterion, and 5.6 percent COHb (CO-Ox, pretest) decreased time to the ST criterion by 12.1 percent ($p<0.001$) relative to clean air exposure. Combining slopes for the 62 individuals yielded a significant ($p<0.005$) regression which indicates that there was a 3.9 percent decrease in time to ST criterion for every 1 percent increase in COHb. Time to onset of angina also was reduced in the same subjects, and regression analysis yielded a significant relationship ($p<0.025$). Both endpoints (time to angina and time to ST change) were highly correlated.

In another study (Sheps et al., 1987), 30 nonsmokers with ischemic heart disease (ages 38–75) were exercised during exposure to 100 ppm CO or air using a 3-day, randomized double blind protocol. Following CO exposure, average COHb levels were 4.1 percent (CO-Ox), representing a 2.2 percent COHb increase from the initial COHb level. In comparing results of air-exposed subjects to CO-exposed subjects as a group, no statistically significant differences were reported in time to onset of angina, maximal exercise time, maximal ST-segment depression, or time to significant ST-segment depression. Although the authors concluded that 4.1 percent COHb did not produce clinically significant effects in the paired subject group, 3 of 30 patients did experience angina on CO-exposure days but not on air-exposure days. Further analysis of the 30 person data base from Sheps et al. (1987) of time to onset of angina that included these three patients indicated a statistically-significant decrease for CO exposure compared to air exposure (Bissette et al., 1986). The same group of researchers (Adams et al., 1988) exposed 30 subjects with obstructive coronary artery disease to either air or sufficient CO to reach COHb levels of 5.9 percent (CO-Ox), representing an average increase of 4.2 percent COHb above initial COHb levels. As in the earlier study, several patients experienced angina on the CO-exposure day and not on the air-exposure day but never the reverse. Results of this study provide statistically significant evidence that exposure to CO induces earlier onset of angina and ventricular dysfunction as well as poorer exercise performance in patients with ischemic heart disease. Although the Sheps et al. (1987) and Adams et al. (1988) studies did not observe statistically-significant changes in time to onset of angina using conventional statistical procedures, results of these studies are not incompatible with the rest of the studies reporting an effect of CO (U.S. EPA, 1991, p. 10-32).

A separate study of effects of CO exposure was conducted with 26 nonsmoking male, angina patients (Kleinman and Whittenberger, 1985; Kleinman et al., 1989). One hour of exposure to 100 ppm CO raised COHb levels to 3.0 percent (CO-Ox), representing an average increase of 1.5 percent COHb over initial COHb level. For the group, CO exposure resulted in a decrease in time to onset of angina by 6.9 percent compared to clean air exposure (Kleinman and Whittenberger, 1985). This was a statistically-significant difference ($p=0.03$). Reanalysis, necessitated by dropping two subjects due to inconsistent medical records, resulted in an average decrease of 5.9 percent ($p=0.046$) in time to onset of angina for CO exposure compared to air exposure (Kleinman et al., 1989). For the eight patients who exhibited depression in the ST segment of ECG traces during exercise, there was a decrease of 10 percent ($p<0.036$) in time to onset of angina and a decrease of 19 percent ($p<0.044$) in time to onset of ST-segment depression.

Allred et al. (1989b, 1991) discuss possible reasons for some differences in results of the above-cited studies. These studies have different designs, types of exercise tests, inclusion criteria (e.g., patient populations), exposure conditions, and measurement methods for COHb. Of the studies, only two (Allred et al,, 1989a,b, 1991; Anderson et al., 1973) investigate more than a single target level of COHb, and of those two, only Allred et al. (1989a,b, 1991) demonstrate a dose-response effect of COHb on time to onset of angina. Different measurement methodologies for COHb also may account for some of the discrepancies between studies. As discussed in Section V.C.1. of the Staff Paper (U.S. EPA, 1992) and in the Criteria Document (U.S. EPA, 1991, pp. 8-70 to 8-74), only Allred et al. (1989a,b, 1991) used both the GC and CO-Ox to measure COHb and found the spread of COHb values to be much greater for the CO-Ox than for the GC. Another difference in the studies was that Allred et ah (1989a,b, 1991) used more rigorous subject entry criteria. All subjects were male, were required to have stable exertional angina and reproducible exercise-induced ST-segment depression and angina, and were required to have either a previous myocardial infarction, angiographic disease or a positive thallium test.

The major conclusion which can be drawn regarding most of the studies

discussed above is that all show a decrease in time to onset of angina at postexposure COHb levels ranging from 2.9 to 5.9 percent (CO-Ox). This represents incremental increases of 1.5 to 4.4 percent COHb from preexposure baseline levels. Therefore, there are clearly demonstrable effects of low-level CO exposure in patients with ischemic heart disease (U.S. EPA, 1991, pp. 10-34 to 10-35). Across-study comparison is depicted in the Criteria Document (U.S. EPA, 1991, p. 10-33), presented as an adaptation from Allred et al. (1989b, 1991), and suggests reasonably good consistency. For purposes of comparison, only optical methods (CO-Ox) were used to avoid confusion.

The adverse nature of the effects described in the five key studies is uncertain due to the range of professional judgments on the clinical significance of small performance decrements produced by exercise and CO exposure. Although some physicians may not be greatly concerned about decrements in performance occurring around 3.0 percent COHb (CO-Ox), consistency across studies of response for both decrease in time to onset of angina and ST-segment depression suggest that the effect does occur and may limit the activity of persons with ischemic heart disease. Bassan (1990) indicates that 58 percent of cardiologists believe that recurrent exercise-induced angina attacks are associated with substantial risk of precipitating myocardial infarction, fatal arrhythmia, or slight but cumulative myocardial damage (U.S. EPA, 1991, p. 10-35). Based on discussions in the Criteria Document (U.S. EPA, 1991) and at the April 30,1991 and March 5,1992 CASAC meetings, staff recommended in the Staff Paper (U.S. EPA, 1992, p. 22) that 2.9 to 3.0 percent COHb (CO-Ox), representing an increase above initial COHb of 1.5 to 2.2 percent COHb, be considered a level of potential adversity for individuals at risk.

3. Effects on Exercise Capacity and Oxygen Uptake

Maximal oxygen uptake and maximal exercise capacity are direct measures of cardiovascular capacity and can provide insight into the impact of CO on the cardiovascular systems of healthy individuals. Although decreases in these attributes may not be very serious in healthy persons for CO exposures typically found in the ambient air, they can be indicative of the extent to which an individual's ability to function normally may be affected while engaging in activities which require high levels of sustained exercise.

Numerous researchers have studied the effects of CO on oxygen uptake and exercise performance in healthy individuals. Several investigators (Klein et al., 1980; Stewart et al., 1978; Weiser et al., 1978; Ekblom and Huot, 1972; Vogel and Gleser, 1972; Pimay et al., 1971) found statistically-significant decreases (8 to 23 percent) in maximal oxygen uptake under conditions of short-term maximal exercise at COHb levels ranging from 5 to 20 percent (CO-Ox). Horvath et al. (1975) found that the lowest level at which COHb marginally influenced maximal oxygen uptake ($p<0.10$) was about 4.3 percent (CO-Ox); COHb levels of 3.3 percent and 4.3 percent (CO-Ox) reduced work time to exhaustion by 4.9 percent and 7 percent, respectively. Similar results were found following exhaustive treadmill exercise at 5 percent COHb (CO-Ox) (Stewart et al., 1978; Klein et al., 1980). Short-term maximal exercise duration has been shown to be reduced by 3 to 38 percent at COHb levels ranging from 2.3 to 7 percent (CO-Ox) (Horvath et al., 1975; Drinkwater et al., 1974; Raven et al., 1974a,b; Weiser et al., 1978; Ekblom and Huot, 1972). Since CO has not been shown to impair submaximal work capacity, changes in short-term maximal exercise should be of concern mainly for competing athletes (U.S. EPA, 1991, p. 10-73).

4. Central Nervous System Effects

A variety of CNS effects has been found to be associated with CO exposures which result in COHb levels of 5 to 20 percent (CO-Ox). These effects include changes in visual perception, hearing, motor performance, sensorimotor performance, vigilance, and other measures of neurobehavioral performance.

Of the behaviors studied, the most sensitive to disruption by COHb are those that require sustained attention or sustained performance. For example, the group of studies on motor and sensorimotor performance, which have used a variety of measures (e.g., fine motor skills, reaction time, and tracking), offer the most consistent evidence for effects occurring at COHb levels as low as 5 percent. Although Winneke (1974) found some effects on steadiness and precision at 10 percent COHb (CO-Ox), several other investigators (Mihevic et al., 1983; O'Donnell, 1971; Seppanen et al., 1977) reported no CO effect at COHb levels ranging from 5.5 to 12.7 percent (CO-Ox). Reaction time was unaffected by COHb levels of 7 and 10 percent (CO-Ox) (Rummo and Sarlanis, 1974; Winneke, 1974), and the pervasive finding is that COHb elevation does not affect reaction time for COHb levels as high as 20 percent (CO-Ox) (U.S. EPA, 1991, p. 10-118). Compensatory tracking was not significantly affected by COHb levels of 5.8 percent (CO-Ox) (Gliner et al., 1983) or by levels of 12 to 13 percent (CO-Ox) (O'Donnell et al., 1971); however, tracking tasks were significantly affected by COHb levels of 5 percent (CO-Ox) (Putz et al., 1976; Putz, 1979). Results of the Putz et al. (1976) study were confirmed by Benignus et al. (1987) but not by Benignus et al. (1990a) when attempting to demonstrate a dose-effect relationship using the same experimental design. Benignus et al. (1990b) discusses possible reasons for high variability between studies, and the Criteria Document (U.S. EPA, 1991, p. 10-121) concludes that COHb elevation produces small decrements in tracking that are sometimes statistically significant. Numerous other studies (Benignus et al., 1977; Bunnell and Horvath, 1988; Christensen et al., 1977; Harbin et al., 1988; Hudnell and Benignus, 1989; McFarland, 1970,1973; McFarland et al., 1944; Roche et al., 1981; von Post-Lingen, 1964) provide additional support for neurobehavioral effects associated with COHb levels above 5 percent.

Even though new information regarding neurobehavioral effects of COHb levels in the range of 5-20 percent (CO-Ox) has been published during the past decade, conditions under which these effects occur are poorly understood (U.S. EPA, 1991, p. 10-143). Because neurobehavioral effects have not yet been demonstrated at COHb levels below 5 percent (CO-Ox), the Staff Paper (U.S. EPA, 1992, p. 24) recommended focussing on the cardiovascular effects which have been reported at lower COHb levels. Standards which protect sensitive populations from adverse cardiovascular effects also should provide adequate protection against adverse neurobehavioral effects of CO occurring in the exposed population.

5. Developmental Toxicity Effects

Developmental toxicity covers a variety of effects in the developing organism including fetal death, structural abnormalities, altered growth and functional deficits. The fetus may be particularly vulnerable to the toxic effects of CO exposure because fetal development often occurs at or near critical tissue oxygenation levels (Longb, 1977). The COHb levels tend to be naturally elevated in the fetus due to differences in uptake and elimination of CO from fetal hemoglobin.

Human data on developmental toxicity of CO are very limited for obvious ethical reasons. Maternal smoking, however, has been associated with a number of adverse health effects, many of which can be attributed to very high CO exposures (500-1000 ppm) from cigarette smoke. These effects include spontaneous abortion and subsequent fetal death due to depressed birth weight, increased number of hospital admissions during the first 5 years of life, and poorer than predicted school performance during the first 11 years of life. These and other effects of smoking are reviewed in a report to the U.S. Surgeon General (National Institute of Child Health and Human Development, 1979). Data (Hoppenbrouwers et al., 1981) supporting a link between environmental CO exposure and sudden infant-death syndrome (SIDS) are suggestive, but further study is needed before any causal relationship can be inferred.

Finally, animal studies have provided evidence of fetal mortality, teratogenicity, reduced body weight, morphological changes, altered cardiovascular development, and neurochemical changes. However, these studies are often conducted at CO levels much greater than those found in the ambient air, and extrapolation to human health effects at ambient CO exposures remains very difficult.

6. Environmental Factors, Drugs, and Other Pollutants

Several additional factors have been investigated for potential interactions with CO that may alter health effects. Among the more important are altitude, drugs, coexposure to other pollutants, and heat stress. Altitude is a matter of concern because of the large populations exposed to CO while living in cities above 1500 meters. While there are some data to support the possibility that effects of inhaling CO and effects of high altitude may be additive (Cooper et al., 1985; McDonagh et al., 1986), several studies even at 2,000 m to 4,500 m show little or no additivity (McGrath, 1988; Horvath, 1988; Horvath and Bedi, 1989). Most other studies have been conducted at CO levels which are too high to be of regulatory use.

There is evidence that interactions of drug effects with CO toxicity can occur in both directions, i.e., CO toxicity may be enhanced by drug use, and toxic or other effects of drugs may be altered by CO exposure. A recent study (Knisely et al., 1989) reported a large interaction of CO exposure and alcohol in mice, demonstrating that alcohol doubled the acute toxicity of CO. In the same study, CO exposure in combination with administration of barbiturates and other psychoactive drugs produced additive but not synergistic effects. Combined exposures of CO and other pollutants have been investigated primarily using animal subjects with only a few human studies being published. No interaction was observed in humans for CO in combination with common ambient air pollutants such as nitrogen dioxide, ozone, and peroxyacetyl nitrate (Raven et al., 1974a,b; Drinkwater et al., 1974; Gliner et al., 1975), although a greater decrement in exercise performance was reported in these studies when heat stress was combined with 50 ppm CO.

The Staff Paper (U.S. EPA, 1992, p. 26) recommended that information on CO in combination with other pollutant exposures and environmental stresses be treated as a margin of safety consideration.

C. Populations Potentially at Risk

In the Administrator's judgment, the available health effects data identify individuals with angina (e.g., history of heart disease) as the group at greatest risk from low-level, ambient air exposures to CO. Based on 1989 data of the American Heart Association (AHA, 1989) and 1990 information from the Department of Health and Human Services (DHHS, 1990), individuals with both diagnosed and undiagnosed ischemic heart disease total approximately 10 to 11 million or about 4.5 percent of the U.S. population. As discussed earlier, concern for these individuals is due to the fact that their condition is due to an insufficient supply of oxygen to cardiac tissue. Further reduction in oxygen reserve capacity by exposure to CO increases the probability of adverse health effects occurring.

Several other groups have been identified in the Criteria Document (U.S. EPA, 1991) and Staff Paper (U.S. EPA, 1992) as being potentially at risk of being sensitive to CO exposure. These groups include: (1) Persons with cerebrovascular disease, (2) those individuals with anemia or chronic obstructive lung disease, and (3) fetuses and young infants. In addition, visitors to high altitude locations may be more susceptible due to lower oxygen content in the air, and those persons using drugs or alcohol may be at greater risk due to the interactive health effects of CO with these substances. For a complete list of probable risk groups, see the Criteria Document (U.S. EPA, 1991, p. 12-1).

For many of the groups identified above, there is little or no experimental evidence to demonstrate that they are at increased risk of CO-induced health effects. However, it is reasonable to expect that individuals with preexisting illness (e.g., congestive heart failure, peripheral vascular or cerebrovascular disease, sickle-cell anemia, hematological disease, chronic obstructive lung disease) which limit oxygen absorption or oxygen transport to body tissues would be somewhat more susceptible to hypoxic (i.e., oxygen starvation) effects of CO (pp. 12-1 and 12-2, U.S. EPA, 1991). Since no human experimental evidence exists which identifies CO effects levels for these other groups, the Administrator is considering the possible effects of CO on these groups only in the determination of what constitutes an adequate margin of safety.

III. Rationale for This Decision

This decision completes the EPA's review of health effects of CO assembled over a 5-year period and contained in the Criteria Document (U.S. EPA, 1991).[2] This review includes the evaluation of key studies published through 1990 incorporated in the Criteria Document (U.S. EPA, 1991), the Staff Paper (U.S. EPA, 1992) assessment of most relevant information contained in the Criteria Document (U.S. EPA, 1991), and the advice and recommendations of the CASAC as presented both in the discussion of these documents at public meetings and in the CASAC's 1991 (McClellan, 1991) and 1992 (McClellan, 1992) "closure letters."

A. Carboxyhemoglobin Levels of Concern

In selecting the appropriate level(s) and averaging time(s) for the primary NAAQS for CO, the Administrator must first determine the COHb levels of concern taking into account a large and diverse health effects data base. The scientific quality and strength of health data are assessed in the Criteria Document (U.S. EPA, 1991) and in the Staff Paper (U.S. EPA, 1992). Based on these assessments, judgments are made here to identify those studies that are most useful in establishing a range of COHb levels to be considered in standard setting. In addition, the more uncertain or less quantifiable evidence is reviewed to determine the lower end of the range that would provide an adequate margin of safety from effects of clear concern. Those judgments relevant to the establishment of an appropriate

[2] As previously noted, the EPA believes that section 307(d) does not require rulemaking procedures where the Administrator concludes that revision of an existing NAAQS is not appropriate.

range of COHb levels are summarized in the discussion below.

The Administrator judges that cardiovascular effects, as measured by decreased time to onset of angina pain and by decreased time to onset of significant ECG ST-segment depression, are the health effects of greatest concern, which clearly have been associated with CO exposures at levels observed in the ambient air. Decrease in time to onset of exercise-induced angina pain is well documented in studies of angina patients whose postexposure COHb levels have been raised to 2.9–5.9 percent ((CO-Ox), which represents incremental increases of 1.5 to 4.4 percent COHb from baseline levels (Allred et al., 1989a,b, 1991; Kleinman et al., 1989; Adams et al., 1988; Sheps et al., 1987; Anderson et al., 1973). Time to onset of significant ECG ST-segment change, which is indicative of myocardial ischemia in patients with documented coronary artery disease and a more objective indicator of ischemia than angina pain, provides supportive evidence of health effects occurring as low as 2.9–3.0 percent COHb ((CO-Ox). In light of the above data and discussions of adverse health consequences in the Criteria Document (U.S. EPA, 1991, p. 10–35) and Staff Paper (U.S. EPA, 1992, p. 29), at the April 30,1991 and March 5,1992 CASAC meetings, and in the July 17, 1991 letter to the Administrator from the CASAC Chairman ((McClellan, 1991), the Administrator concludes that CO exposures resulting in COHb levels of 2.9–3.0 percent ((CO-Ox) or higher in persons with heart disease have the potential to increase the risk of decreased time to onset of angina pain and ST-segment depression. As stated by McClellan ((1991), "Among health professionals there is a range of views as to the clinical significance of these changes with the dominant view being that the changes should be considered as adverse or a harbinger of adverse effects." It is important that standards be set to appropriately reduce the risk of ambient exposures which produce COHb levels that could induce such potentially adverse effects.

Clinical importance of cardiovascular effects associated with exposures to CO resulting in COHb levels of 2 to 3 percent remains less certain. One recent study (Allred et al., 1989a,b) provides evidence of a 5.1 percent decrease in time to ST-segment depression at 2.0 percent COHb when using the CC to measure COHb levels. Although it is possible that there is no threshold for these effects even at lower COHb levels, the health significance of such small changes in ST-segment depression appears to be relatively trivial. The Administrator, therefore, concludes that results suggesting cardiovascular effects in angina patients when COHb levels are between 2.0 and 2.9 percent only be considered in evaluating whether the current CO standards provide an adequate margin of safety.

B. Margin of Safety

There are several factors which the Administrator believes should be considered in evaluating the adequacy of the current CO NAAQS: (a) short-term reduction in maximal work capacity has been measured in trained athletes exposed to CO sufficient to produce COHb levels as low as 2.3 to 7 percent; (b) the wide range of human susceptibility to CO exposures and ethical considerations in selecting subjects for experimental purposes together suggest that the most sensitive individuals have not been studied; (c) animal studies of developmental toxicity and human studies of the effects of maternal smoking provide evidence that exposure to high concentrations of CO can be detrimental to fetal development, although very little is known about the effects of ambient CO exposures on the developing fetus; (d) though little is known about effects of CO on potentially sensitive populations other than those with ischemic heart disease, there is reason for concern about visitors to high altitudes, individuals with anemia or respiratory disease, and the elderly; (e) impairment of visual perception, sensorimotor performance, vigilance or other CNS effects has not been demonstrated to be caused by CO concentrations commonly found in the ambient air; however, short-term peak CO exposures may be responsible for impairments which could be a matter of concern for complex activities such as driving a car; (f) limited evidence suggests concern for individuals exposed to CO concurrently with drug use (e.g., alcohol) during heat stress, or coexposure to other pollutants; (g) large uncertainties remain regarding modelling COHb formation and estimating human exposure to CO which could lead to overestimation or underestimation of COHb levels in the population associated with attainment of a given CO NAAQS; and (h) COHb measurements made using the CO-Ox may not reflect COHb levels in angina patients studied, thereby creating uncertainty in establishing a lowest effects level for CO.

In summary, the Administrator concludes that the lowest COHb level at which adverse effects have been demonstrated in persons with angina is around 2.9–3.0 percent, representing an increase of 1.5 percent above baseline when using the CO-Ox to measure COHb. These data serve to establish the upper end of the range of COHb levels of concern. Taking into account uncertainties in the data, the less significant health endpoints, and less quantifiable data on other potentially sensitive groups, staff recommends that the lower end of the range be established at 2.0 percent COHb. Below this level, the potential for public health risk appears to be small. The Administrator, therefore, concludes that results suggesting cardiovascular effects in angina patients when COHb levels are between 2.0 and 2.9 percent only be considered in evaluating whether the current CO standards provide an adequate margin of safety.

C. Relationship Between CO Exposure and COHb Levels

In order to set ambient CO standards based on an assessment of health effects at various COHb levels, it is necessary to estimate the ambient CO concentrations that are likely to result in COHb levels of concern. The Criteria Document (U.S. EPA, 1991, p. 9-21)) concludes that the best all around model for predicting COHb levels is the Coburn, Forster, Kane (CFK) differential equation (Coburn et al., 1965)). The CFK model estimates COHb levels resulting from exposure to CO concentrations as a function of time and various physiological and environmental factors (e.g., blood volume, endogenous CO production rate, ventilation rate, altitude).

Over the last 20 years, modelers have developed and evaluated both linear and nonlinear solutions to the CFK model. The linear CFK model assumes that O_2Hb is constant and does not vary with COHb level. The nonlinear CFK model incorporates the interdependence between O_2Hb and COHb. At COHb levels below 6 percent, both approaches give estimates that are within 0.5 percent COHb (Smith, 1990)). While the linear CFK model is easier to solve and gives approximately the same COHb estimate in the range of interest (i.e., 1 to 5 percent COHb), the nonlinear solution tends to be more accurate physiologically (U.S. EPA, 1992, p. 12)). With the assumption of a linear relationship between O_2Hb and COHb, there is an analytical solution to the nonlinear CFK equation (Muller and Barton, 1987)).

The Staff Paper (U.S. EPA, 1992, p. 13) provides baseline estimates (i.e., typical physiological parameters are used) of COHb levels expected to be reached by nonsmokers exposed to various constant concentrations of CO

for either 1 or 8 hours based on the CFK model. (Smokers are not included because they have voluntarily exposed themselves to high CO levels.) There are, however, two major uncertainties involved in estimating COHb levels resulting from exposure to CO concentrations. First, among the population with cardiovascular disease, or any other group of interest, there is a distribution for each of the physiological parameters used in the CFK model. Past work (Biller and Richmond, 1982) has shown that these variations are sufficient to produce noticeable deviations from the COHb levels. Second, predictions based on exposure to constant CO concentrations can underestimate or overestimate response of individuals exposed to widely fluctuating CO levels that typically occur in the ambient environment (Biller and Richmond, 1992).

D. Estimating Population Exposure

The Agency's review includes an analysis of CO exposures expected to be experienced by residents of Denver, Colorado, under air quality scenarios related to the current situation when the 8-hour CO NAAQS is just attained. (The 8-hour CO NAAQS is modeled because it is the "controlling standard" in Denver and in every other U.S. nonattainment area for CO.) The analysis includes passive smoking and gas stove CO emissions as indoor sources of CO pollution. However, it does not include other less-common CO sources (e.g., wood stoves, fireplaces, and faulty furnaces). Although these sources of exposure may be of concern for such high risk groups as individuals with cardiovascular disease, pregnant women, and their unborn children, the contribution of indoor sources cannot be effectively mitigated by ambient air quality standards. The exposure analysis is abstracted in the Staff Paper (U.S. EPA, 1992) and reported in more complete form in Johnson et al. (1992).

The analysis indicates that if the current 8-hour standard is attained, the proportion of the nonsmoking population with cardiovascular disease experiencing exposures at or above 35 ppm for 1 hour and 9 ppm for 8 hours decreases by an order of magnitude or more, down to less than 1 percent of the total person-days in that population. Likewise, attaining the current 8-hour standard reduces the proportion of the nonsmoking cardiovascular-disease population person days at or above COHb levels of concern by an order of magnitude or more. At the 8-hour standard, the EPA estimates that fewer than 0.1 percent of the nonsmoking cardiovascular-disease population would experience a COHb level ≥ 2.1 percent (U.S. EPA, 1992, p. 40). A smaller population is estimated to exceed higher COHb percentages.

E. Decision on the Primary Standards

Based on this assessment, and considering the 1985 review of similar CO effects and effects levels, the Administrator concludes that the evaluation of adequacy of the current CO standards should focus on reducing the number of individuals with cardiovascular disease from being exposed to CO levels in the ambient air that would result in COHb levels of 2.1 percent or greater. Standards that protect against COHb levels at the lower end of the range should provide an adequate margin of safety against effects of uncertain occurrence, as well as those of clear concern that have been associated with COHb levels in the upper-end of the range.

Based on the exposure analysis results described above, the Administrator concludes that relatively few people of the cardiovascular sensitive population group analyzed will experience COHb levels ≥ 2.1 percent when exposed to CO levels in the absence of indoor sources when the current ambient standards are attained. The analysis also indicates, however, that certain indoor sources (e.g., passive smoking, gas stove usage) contribute to total CO exposure. In addition, other indoor CO sources such as wood stoves and fireplaces also contribute to total CO exposure, but they were not explicitly modeled. Although these sources of exposure may be of concern for such high risk groups as individuals with cardiovascular disease, pregnant women, and their unborn children, the contribution of indoor sources cannot be effectively mitigated by ambient air quality standards.

When the EPA promulgated CO primary NAAQS on April 30, 1971 (36 FR 8186), two averaging times—1-hr and 8-hr—were selected. The 8-hr standard was chosen because most individuals, even at rest, appear to approach equilibrium levels of COHb after 8 hours of exposure. In addition the 8-hr period approximates blocks of time for which people are often exposed in a particular location or activity (e.g., sleeping, working) and provides a good indicator for tracking continuous exposures that occur during any 24-hr period. The 1-hr standard Was chosen because a 1-hr averaging period provides a better indicator of short-term health effects of CO. The 1-hr standard provides reasonable protection from effects which might be encountered from very short duration peak (bolus) exposures in the urban environment. Review of current scientific information in the Criteria Document (U.S. EPA, 1991) indicates that these reasons for choosing averaging times for the CO standards remain valid and there are no compelling arguments for selecting new or different averaging times. The Administrator also considered and concurs with the staff recommendations contained in the Staff Paper (U.S. EPA, 1992) that both averaging times be retained for primary CO standards.

For the above reasons, the Administrator determines under section 109(d)(1) that revisions of the current 1-hr (35 ppm) and 8-hr (9 ppm) primary standards for CO are not appropriate at this time. As discussed more fully above, this determination is based on and completes the EPA's review of the health effects information contained in the final Criteria Document (U.S. EPA, 1991), the assessment in the final Staff Paper (U.S. EPA, 1992), and comments made by the CASAC (McClellan, 1991, 1992).

IV. Final Decision Not To Revise the Standards

The EPA has completed its review and revision of the air quality criteria document concerning the national primary and secondary air quality standards for CO and has made a final decision pursuant to CAA section 109(d)(1) that no revision of the standards for CO is appropriate. This decision is a final Agency action based on a determination of nationwide scope and effect. It is, therefore, subject to judicial review under CAA section 307(b) exclusively in the U.S. Court of Appeals for the District of Columbia Circuit. Any petition for judicial review of this final action must be filed within sixty days after August 1, 1994.

V. Regulatory Impacts

A. Regulatory Impact Analysis

Under Executive Order 12866 [58 FR 51,735 (October 4, 1993)], the Agency must determine whether the regulatory action is "significant" and, therefore, subject to Office of Management and Budget (OMB) review and the requirements of the Executive Order. The Order defines "significant regulatory action" as one that is likely to result in a rule that may:

(1) have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or

State, local, or tribal governments or communities;

(2) create a serious inconsistency or otherwise interfere with an action taken or planned by another Agency;

(3) materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations or recipients thereof; or

(4) raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order."

Pursuant to the terms of Executive Order 12866, the OMB has notified the EPA that this action is a "significant regulatory action" within the meaning of the Executive Order. For this reason, this action was submitted to the OMB for review. Changes made in response to the OMB suggestions or recommendations will be documented in the public record.

B. Impact on Small Entities

Under the Regulatory Flexibility Act (RFA), 5 U.S.C. 601 et seq., the EPA must prepare initial and final regulatory flexibility analyses assessing the impact of certain decisions on small entities. These requirements are inapplicable to rules or other actions for which the EPA is not required by the Administrative Procedure Act (APA), 5 U.S.C. 551 et seq., or other law to publish a notice of proposed rulemaking [(5 U.S.C. 603(a), 604(a)]. Under section 307(d) of the Act, as the EPA interprets it, neither the APA nor the Act requires rulemaking procedures where the Agency decides to retain existing NAAQS without change. Accordingly, the EPA has determined that the impact assessment requirements of the RFA are inapplicable to this final decision.

VI. Other Reviews

This decision was submitted to the OMB for review. Comments from the OMB and the EPA's responses to these comments are available for public inspection at the EPA's Air and Radiation Docket Information Center (Docket No. A-93-05), South Conference Center, Room 4, Waterside Mall, 401 M Street, S.W., Washington, DC.

List of Subjects in 40 CFR Part 50

Environmental protection, Air pollution control, Carbon monoxide, Ozone, Sulfur oxides, Particulate matter, Nitrogen dioxide, Lead.

Dated: July 15, 1994.

Carol M. Browner,

Administrator.

References

Adams, K.F., Koch, G., Chatterjee, B., Goldstein, G.M., O'Neil, J.J., Bromberg, P.A., Sheps, D.S., McAllister, S., Price, C.J., Bissette, J. (1988), Acute elevation of blood carboxyhemoglobin to 6% impairs exercise performance and aggravates symptoms in patients with ischemic heart disease, J. Am. Coll. Cardiol. 12: 900-909.

Allred, E.N., Bleecker, E.R., Chaitman, B.R., Dahms, T.E., Gottlieb, S.O., Hackney, J.D., Pagano, M., Selvester, R.H., Walden, S.M., Warren, J. (1989a), Short-term effects of carbon monoxide exposure on the exercise performance of subjects with coronary artery disease, N. Engl. J. Med. 321:1426-1432.

Allred, E.N., Bleecker, E.R., Chaitman, B.R., Dahms, T.E., Gottlieb, S.O., Hackney, J.D., Hayes, D., Pagano, M., Selvester, R.H., Walden, S.M., Warren, J. (1989b), Acute effects of carbon monoxide exposure on individuals with coronary artery disease, Cambridge, MA: Health Effects Institute; research report no. 25.

Allred, E.N., Bleecker, E.R., Chaitman, B.R., Dahms, T.E., Gottlieb, S.M., Hackney, J.D., Pagano, M., Selvester, R.H., Walden, S.M., Warren, J. (1991), Effects of carbon monoxide on myocardial ischemia, Environ. Health Perspect. 91: 89-132.

American Petroleum Institute v. Costle (1982), 665 F.2d 1176 (D.C. Cir. 1981), *cert. denied* 102 S. Ct. 1737.

American Heart Association (1989), 1990 heart and stroke facts, Dallas, TX, American Heart Association.

Anderson, E.W., Andelman, R.J., Strauch, J.M., Fortuin, N.J., Knelson, J.H. (1973), Effect of low-level carbon monoxide exposure on onset and duration of angina pectoris: A study on 10 patients with ischemic heart disease, Ann. Intern. Med. 79: 46-50.

Aronow, W.S. (1981), Aggravation of angina pectoris by two percent carboxyhemoglobin, American Heart Journal 101:154-156.

Aronow, W.S. (1978), Effect of passive smoking on angina pectoris, N. Eng. J. Med. 229: 21-24.

Aronow, W.S., Cassidy, J. (1975), Effect of carbon monoxide on maximal treadmill exercise: A study in normal persons, Ann. Intern. Med. 83: 496-499.

Aronow, W.S., Cassidy, J., Vangrow, J.S., March, H., Kern, J.C., Goldsmith, J.R., Khemka, M., Pagano, J., Vawter, M. (1974a), Effect of cigarette smoking and breathing carbon monoxide on cardiovascular hemodynamics on anginal patients, Circulation 50: 340-347.

Aronow, W.S., Stemmer, E.A., Isbell, M.W. (1974b), Effect of carbon monoxide exposure on intermittent claudication, Circulation 49: 415-417.

Aronow, W.S., Ferlinz, J., Glauser, F. (1977), Effect of carbon monoxide on exercise performance in chronic obstructive pulmonary disease, Am. J. Med 63: 904-908.

Aronow, W.S., Harris, D.N., Isbell, M.W., Rokaw, S.N., Imparato, B. (1972), Effect of freeway travel on angina pectoris, Ann. Intern. Med. 77: 669-676.

Aronow, W.S., and Isbell, M.W. (1973), Carbon monoxide effect on exercise-induced angina pectoris. Ann. Intern, Med. 79: 392-395.

Bàssan, M.M. (1990), Letter to the Editor, N. Engl. J. Med. 332: 272.

Beard, R.R., Wertheim, G.A. (1967), Behavioral impairment associated with small doses of carbon monoxide, Am. J. Public Health 57: 2012-2022.

Benignus, V.A., Muller, K.E., Barton, C.N., Prah, J.D. (1987), Effect of low level carbon monoxide on compensatory tracking and event monitoring, Neurotoxicol. Teratol. 9: 227-234.

Benignus, V.A., Muller, K.E., Smith, M.J., Pieper, K.S., Prah, J.D. (1990a), Compensatory tracking in humans with elevated carboxyhemoglobin, Neurotoxicol. Teratol. 12:105-110.

Benignus, V.A., Muller, K.E., Mallot, C.M. (1990b), Dose-effects functions for carboxyhemoglobin and behavior, Neurotoxicol. Teratol. 12:111-118.

Benignus, V.Ai, Otto, D.A., Prah, J.D., Benignus, G. (1977), Lack of effects of carbon monoxide on human vigilance, Percept. Mot. Skills 45:1007-1014.

Biller, W.F., Richmond, H.M. (1982), Sensitivity analysis on Coburn model predictions of COHb levels associated with alternative CO standards, Research Triangle Park, NC: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA contract no. 68-02-3600.

Biller, W.F., Richmond, H.M. (1992), COHb Module for a Probabilistic CO NEM, Research Triangle Park, NC: U.S. Environmental Protection Agency, Contract No: 68 DO 0129.

Bunnell, D.E., Horvath, S.M. (1988), Interactive effects of physical work and carbon monoxide on cognitive task performance, Aviat. Space Environ. Med. 59:1133-1138.

Christensen, C.L., Gliner, J.A., Horvath, S.M., Wagner, J.A. (1977), Effects of three kinds of hypoxias on vigilance performance, Av. Sp. Env. Med. 48: 491-496.

Cobum, R.F., Forster, R.E., Kane, P.B. (1965), Considerations of the physiological variables that determine the blood carboxyhemoglobin concentration in man, J. Clin. Invest 44:1899-1910.

Cooper, R.L., Dooley, B.S., McGrath, J.J., McFaul, S.J., Kopetzky, M.T. (1985), Heart weights and electrocardiograms in rats breathing carbon monoxide at altitude, Fed. Proc. Fed. Am. Soc. Exp. Biol. 44: 1040.

DHHS (1990), U.S. Department of Health and Human Services, Vital and health statistics: current estimates from the National Health Interview Survey, 1989, Hyattsville, MD: Public Health Service, Statistics, DHHS publication no. (PHS)90-1504, (Series 10: data from the National Health Survey no. 176).

Drinkwater, B.L., Raven, P.B., Horvath, S.M., Gliner, J.A., Ruhling, R.O., Bolduan, N.W., Taguchi, S., (1974) Air pollution, exercise, and heat stress, Arch. Environ. Health 28:177-181.

Ekblom, B., Huot, R. (1972), Response to submaximal and maximal exercise at different levels of carboxyhemoglobin, Acta Physiol. Scand. 86: 474-482.

Friedlander, S.K., Chairman, Clean Air Scientific Advisory Committee (1982), Letter to Ann M. Gorsuch, EPA Administrator.

Gliner, J.A., Raven, P.B., Horvath, S.M., Drinkwater, B.L., Sutton, J.C. (1975), Man's physiologic response to long-term work during thermal and pollutant stress, J. Appl. Physiol. 39: 628-632.

Gliner, J.A., Horvath, S.M., Mihevic, P.M. (1983), Carbon monoxide and human performance in a single and dual task methodology, Aviat. Space Environ. Med. 54: 714-717.

Hoppenbrouwers, T., Calub, M., Arakawa, K., Hodgman, J. (1981), Seasonal relationship of sudden infant death syndrome and environmental pollutants, Am. J. Epidemiol, 113: 623-635.

Horvath, S.M., Raven, P.B., Dahms, T.E., Gray, D.J. (1975), Maximal aerobic capacity at different levels of carboxyhemoglobin, J. Appl. Physiol. 38: 300-303.

Horvath, S.M., Bedi, J.F., Wagner, J.A., Agnew, J. (1988), Maximal aerobic capacity at several ambient concentrations of CO at several altitudes, J. Appl. Physiol. 65: 2696-2708.

Horvath, S.M., Bedi, J.F. (1989), Alteration in carboxyhemoglobin concentrations during exposure to 9 ppm carbon monoxide for 8 hours at sea level and 2134 m altitude in a hypobaric chamber, JAPCA 39: 1323-1327.

Horvath, S.M., Ayres, A.M., Sheps, D.S., Ware, J. (1983), (Letter to Dr. Lester D. Grant, including the peer-review committee report on Dr. Aronow's studies.] May 25,1983, Available from: U.S. Environmental Protection Agency, Central Docket Section, Washington, D.C., docket no. OAQPS 79-7, IV-H-58.

Hudnell, H.K., Benignus, V.A. (1989), Carbon monoxide exposure and human visual function thresholds, Neurotoxicol. Teratol. 11: 363-371.

Johnson, T., Capel, J., Paul, R, Wijnberg, L. (1992), Estimation of Carbon Monoxide Exposure and associated Carboxyhemoglobin Levels in Denver Residents Using a Probablistic version of NEM, Prepared by International Technology for U.S. EPA Office of Air Quality Planning and Standards, Durham, N.C., Contract No. 68 DO 0062.

Johnson, T., Paul, R.A. (1983), The NAAQS Exposure Model (NEM) Applied to Carbon Monoxide (Final), Prepared by PEDCo Environmental, Inc., for U.S. EPA, Office of Air Quality Planning and Standards, Durham, N.C., Contract No. 68-02-3390, EPA-450/5-83-003.

Klein, J.P., Forster, H.V., Stewart, R.D., Wu, A. (1980), Hemoglobin affinity for oxygen during short-term exhaustive exercise, J; Appl. Physiol. 48: 236-242.

Kleinman, M.T., Davidson, D.M., Vandagriff, R.B., Caiozzo, V.J., Whittenberger, J.L. (1989), Effects of short-term exposure to carbon monoxide in subjects with coronary artery disease, Arch. Environ. Health 44: 361-369.

Kleinman, M., Whittenberger, J. (1985), Effects of short-term exposure to carbon monoxide in subjects with coronary artery disease, Sacramento, CA: California State Air Resources Board, report no. ARB-R-86/276. Available from: NTIS, Springfield, VA PB86-217494.

Knisely, J.S., Rees, D.C., Balster, R.L. (1989), Effects of carbon monoxide in combination with behaviorally active drugs on fixed-ratio performance in the mouse, Neurotoxicol. Teratol. 11: 447-452.

Lead Industries Association, Inc. v. EPA (1980), 647 F.2d 1130 (D.C. Cir. 1980), *cert. denied* 101 S. Ct. 621.

Longo, L.D. (1977), The biological effects of carbon monoxide on the pregnant woman, fetus, and newborn infant, Am. J. Obstet. Gynecol. 129: 69-103.

McClellan, R.O., Chairman, Clean Air Scientific Advisory Committee (1991), Letter to William K. Reilly, EPA Administrator, July 17,1991.

McClellan, R.O., Chairman, Clean Air Scientific Advisory Committee (1992), Letter to William K. Reilly, EPA Administrator, August 11,1992.

McFarland, R.A. (1973), Low level exposure to carbon monoxide and driving performance, Arch. Environ. Health 27: 355-359.

McFarland, R.A. (1970), The effects of exposure to small quantities of carbon monoxide on vision, In: Coburn, R.F., ed. Biological effects of carbon monoxide, Ann. N.Y. Acad. Sci. 174: 301-312.

McFarland, R.A., Roughton, F. J. W., Halperin, M.H., Niven, J.R. (1944), The effects of carbon monoxide and altitude on visual thresholds, J. Aviat. Med. 15: 381-394.

Mihevic, P.M., Gliner, J.A., Horvath, S.M. (1983), Carbon monoxide exposure and information processing during perceptual-motor performance, Int. Arch. Occup. Environ. Health 51: 355-363.

Muller, K.E., Barton, C.N. (1987), A nonlinear version of The Coburn, Forster and Kane model of blood carboxyhemoglobin, Atmos. Environ. 21: 1963-1968.

National Institute of Child Health and Human Development, (1979), Pregnancy and infant health. In: Smoking and health: a report of the Surgeon General. Washington, DC, U. S. Department of Health, Education, and Welfare, DHEW publication no. PHS 79-50066.

O'Donnell, R.D., Mikulka, P, Heiriig, P., Theodore, J. (1971), Low level carbon monoxide exposure and human psychomotor performance, Toxicol. Appl. Pharma-col. 18: 593-602.

Pirnay, F., Dujardin, J., Deroanne, R., Petit, J.M. (1971), Muscular exercise during intoxication by carbon monoxide, J. Appl. Physiol. 31: 573-575.

Putz, V.R. (1979) The effects of carbon monoxide on dual- task performance, Human Factors 21:13-24.

Putz, V.R., Johnson, B.L., Setzer, J.V. (1976), Effects of CO on vigilance performance: effects of low level carbon monoxide on divided attention, pitch discrimination, and the auditory evoked potential, Cincinnati, OH, U.S. Department of Health, Education, and Welfare, National Institute for Occupational Safety and Health, Available from: NTIS, Springfield, VA, PB-274219.

Raven, P.B., Drinkwater, B.L., Horvath, S.M., Ruhling, R.O., Gliner, J.A., Sutton, J.C. Bolduan, N.W. (1974a), Age, smoking habits, heat stress, and their interactive effects with carbon monoxide and peroxyacetylnitrate on man's aerobic power, Int. J. Biometeorol. 18: 222-232.

Raven, P.B., Drinkwater, B.L., Ruhling, R.O., Bolduan, N., Taguchi, S., Gliner, J., Horvath, S.M. (1974b), Effect of carbon monoxide and peroxyacetyl nitrate on man's maximal aerobic capacity, J. Appl. Physiol. 36: 288-293.

Rodkey, F.L., J.D. O'Neal, and H.A. Collison (1969), Oxygen and carbon monoxide equilibria of human adult hemoglobin at atmospheric and elevated pressure, Blood 33: 57-65.

Roughton, F.J.W. (1970), The equilibrium of carbon monoxide with human hemoglobin in whole blood, In: Biological effects of carbon monoxide, proceedings of a conference, New York, NY, Ann. N.Y. Acad. Sci. 174 (art.1) 177-188.

Rummo, N., Sarlanis, K. (1974), The effect of carbon monoxide on several measures of vigilance in a simulated driving task, J. Saf. Res. 6:126-130.

Seppanen, A. (1977), Physical work capacity in relation to carbon monoxide inhalation and tobacco smoking, Ann. Clin. Res. 9: 269-274.

Sheps, D., Adams, K.F., Jr., Bromberg, P.A., Goldstein, G.M., O'Neil, J.J., Horstman, D., Koch, G. (1987), Lack of effect of low levels of carboxyhemoglobin on cardiovascular function in patients with ischemic heart disease, Arch. Environ. Health 42:108-116.

Smith, M.V. (1990), Comparing solutions to the linear and nonlinear CFK equations for predicting COHb formation, Math. Biosci. 99: 251-263.

Stewart, R.D., Newton, P.E., Kaufman, J., Forster, H.V., Klein, J.P., Keelen, M.H., Jr., Stewart, D.J., Wu, A., Hake, C.L. (1978), The effect of a rapid 4% carboxyhemoglobin saturation increase on maximal treadmill exercise, New York, NY, Coordinating Research Council, Inc., report no. CRC-APRAC-CAPM-22-75, Available from NTIS, Springfield, VA, PB-296627.

U.S. Department of Health, Education, and Welfare (1970), Air Quality Criteria for Carbon Monoxide, AP-62.

U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office (1978), Altitude as a Factor in Air Pollution, U.S. EPA No. 600/9-78-015, Research Triangle Park, N.C.

U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office (1979a), Air Quality Criteria for Carbon Monoxide, U.S. EPA No. EPA/600/8-79-022, Research Triangle Park, NC, Available from: NTIS, Springfield, VA, PB81-244840.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards (1979b), Assessment of Adverse Health Effects from Carbon Monoxide and Implications for Possible Modifications of the Standard, Research Triangle Park, NC.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards (1984a), Review of the NAAQS for Carbon Monoxide: Reassessment of Scientific and Technical Information, U.S. EPA No. EPA-450/5-84-004, Research Triangle Park, NC

U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office (1984b), Revised Evaluation of Health Effects Associated with Carbon Monoxide Exposure: An Addendum to the 1979 EPA Air Quality Document for Carbon Monoxide, U.S. EPA No. EPA-600/8-83-033F, Research Triangle Park, N.C., Available from: NTIS, Springfield, VA, PB85-103471.

U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office (1991), Air Quality Criteria for Carbon Monoxide, U.S. EPA No. EPA/600/8-90/045F, Research Triangle Park, NC.

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards (1992), Review of the National Ambient Air Quality Standards for Carbon Monoxide: Assessment of Scientific and Technical Information: OAQPS Staff Paper, U.S. EPA No. EPA/452/R-92-004, Research Triangle Park, NC.

Vogel, J.A., Gleser, M.A. (1972), Effects of carbon monoxide on oxygen transport during exercise, J. Appl. Physiol. 32: 234-239.

Von Post-Ungen, M.L. (1964), The significance of exposure to small concentrations of carbon monoxide, Proc. R. Soc. Med. 57:1021-1029.

Weiser, P.C., Morrill, C.G., Dickey, D.W., Kurt, T.L.; Cropp, G.J.A. (1978), Effects of low-level carbon monoxide exposure on the adaptation of healthy young men to aerobic work at an altitude of 1,610 meters, In: Environmental Stress, Individual Human Adaptations. L.J. Folinsbee, J.A. Wagner, J.F. Borgia, B.L. Drinkwater, J.A. Gliner, and J.F. Bedi, eds., Academic Press, New York, pp. 101-110.

Winneke, G (1974), Behavioral effects of methylene chloride and carbon monoxide as assessed by sensory and psychomotor performance, In: Behavioral Toxicology, Early Detection of Occupational Hazards, Proceedings of a Workshop, National Institute for Occupational Safety and Health and University of Cincinnati, Cincinnati, Ohio, June 24-29,1973, C. Xintaras, B.L. Johnson, and I. de Groot, eds., HEW Publication No. (NIOSH) 74-126, U.S. Department of Health, Education and Welfare.

Wyman, J., Bishop, G.^Richey B., Spokane, R., Gill, S. (1982), Examination of Haldane's first law for the partition of carbon monoxide and oxygen to hemoglobin Ao, Biopolymers 21:1735-1747.

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40 CFR Part 799

[OPPTS-42168; FRL 4642-3]

Testing Consent Order For Bisphenol A Diglycidyl Ether

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final Consent Agreement and Order; Final rule.

SUMMARY: EPA has issued a Testing Consent Order that incorporates an Enforceable Consent Agreement (ECA) pursuant to the Toxic Substances Control Act (TSCA), with the Dow Chemical Company, Shell Oil Company, and Ciba-Geigy Corporation, (the Companies) who have agreed to perform certain health effects tests and an exposure evaluation test with bisphenol A diglycidyl ether (DGEBPA; CAS No. 1675-543). This document summarizes the ECA, amends 40 CFR 799.5000 by adding DGEBPA to the list of chemical substances and mixtures subject to ECAs and deletes DGEBPA from the proposed test rule for the category glycidol and its derivatives. Accordingly, the export notification requirements of 40 CFR part 707 apply to DGEBPA.

EFFECTIVE DATE: August 1, 1994.

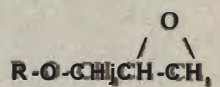
FOR FURTHER INFORMATION CONTACT: Susan Hazen, Director, Environmental Assistance Division (7408), Office of Pollution Prevention and Toxics, Rm. E-543B, 401 M St., SW., Washington, DC 20460, (202) 554-1404, TDD (202) 554-0551.

SUPPLEMENTARY INFORMATION: This document amends 40 CFR 799.5000 by adding DGEBPA to the list of chemical substances and mixtures subject to ECAs and export notification requirements.

I. Regulatory History

A. ITC Designation

In its Third Report to the Administrator of the Environmental Protection Agency, published in the Federal Register on October 30,1978 (43 FR 50630), the Interagency Testing Committee (ITC) designated the category of "glycidol and its derivatives" for priority consideration for health effects testing in the following areas: mutagenicity, carcinogenicity, and other adverse health effects, with particular emphasis on the reproductive system. Epidemiology studies were also recommended. The rationale for the original designation is discussed in the Federal Register of October 30,1978 (43 FR 50630), This chemical category was defined by the ITC as all substances of the general formula:



where R is a hydrogen atom or any alkyl, aryl, or acyl group. R is unrestricted as to the number and type of substitutes it may carry.

In evaluating the testing needs for glycidyls, EPA considered all relevant information, including the following: information presented in the ITC's report; information regarding production volume, use, exposure, and release reported by manufacturers of glycidyls under the TSCA section 8(a) Preliminary Assessment Information Rule (40 CFR part 712); health and safety studies submitted under TSCA section 8(d) Health and Safety Reporting Rule (40 CFR part 716) for glycidyls; and published and unpublished information available to EPA. On December 30,1983, EPA published an advanced notice of proposed rulemaking (ANPR) in the Federal Register (48 FR 57562) to require testing glycidyls under section 4(a) of TSCA.

EPA evaluated and responded to public comments on the ANPR in a document (Ref. 1), entitled "Support Document for Glycidol and its Derivatives: Responses to Public Comments on the Advance Notice of Proposed Rulemaking" (December, 1989).

In addition, EPA developed a technical support document for glycidol and its derivatives (Ref. 2). This document includes data on the identity and chemical/physical properties of the substances contained in this chemical category, as well as information bn the production, uses, chemical fate, human exposure, and health effects for these substances. Subsequently, EPA