Environmental Health Criteria 13

Carbon Monoxide

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World Health Organization

INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY

ENVIRONMENTAL HEALTH CRITERIA 13

Carbon Monoxide

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NOTE TO READERS OF THE CRITERIA DOCUMENTS

While every effort has been made to present information in the criteria documents as accurately as possible without unduly delaying their publication, mistakes might have occurred and are likely to occur in the future. In the interest of all users of the environmental health criteria documents, readers are kindly requested to communicate any errors found to the Division of Environmental Health, World Health Organization, Geneva, Switzerland, in order that they may be included in corrigenda which will appear in subsequent volumes.

In addition, experts in any particular field dealt with in the criteria documents are kindly requested to make available to the WHO Secretariat any important published information that may have inadvertently been omitted and which may change the evaluation of health risks from exposure to the environmental agent under examination, so that the information may be considered in the event of updating and re-evaluation of the conclusions contained in the criteria documents.

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ENVIRONMENTAL HEALTH CRITERIA FOR CARBON MONOXIDE

A WHO Task Group on Environmental Health Criteria for Carbon Monoxide met in Geneva from 11 to 17 October 1977. Dr V.B. Vouk, Chief, Control of Environmental Pollution and Hazards, opened the meeting on behalf of the Director-General. The Task Group reviewed and revised the second draft of the criteria document and made an evaluation of the health risks from exposure to carbon monoxide.

The first and second drafts were prepared by Dr S.M. Horvath of the Institute of Environmental Studies, University of California, Santa Barbara, USA. The comments on which the second draft was based were received from the national focal points for the WHO Environmental Health Criteria Programme in Bulgaria, Canada, Czechoslovakia, France, Netherlands, Poland, USSR, and USA and from the International Labour Organisation (ILO), Geneva, the Food and Agriculture Organization of the United Nations (FAO), Rome, the United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris, the United Nations Industrial Development Organization (UNIDO), Vienna, the Permanent Commission and International Association on Occupational Health, the Commission on Atmospheric Environment, International Union of Pure and Applied Chemistry (IUPAC), and from the Pan American Sanitary Engineering Center (CEPIS).

The collaboration of these national institutions, international organizations and WHO collaborating centres is gratefully acknowledged. Without their assistance this document would not have been completed. The Secretariat wishes to thank, in particular, Professor P.J. Lawther and Mr R.E. Waller of the Medical Research Council Toxicology Unit, St Bartholomew's Hospital Medical College, London, and Dr G. Winneke of the Institute for Air Hygiene and Silicosis Research, Düsseldorf, for their help in the scientific editing of the document.

This document is based primarily on original publications listed in the reference section. However, several recent publications broadly reviewing health aspects of carbon monoxide have also been used including those of the Commission of the European Communities (1974), NAS/NRC (1977), US Department of Health, Education and Welfare (1970, 1972), and Committee on the Challenges of Modern Society (1972).

Details of the WHO Environmental Health Criteria Programme, including some of the terms frequently used in the documents, may be found in the introduction to the publication "Environmental Health Criteria 1 -- Mercury" published by the World Health Organization, Geneva, 1976, and now available as a reprint.

The following conversion factors[a] have been used in this document:

carbon monoxide	1 ppm = 1145 μg/m^3	1 μg/m^3 = 0.873 ppm
methylene chloride	1 ppm = 3480 μg/m^3	1 μg/m^3 = 0.288 ppm
nitrogen dioxide	1 ppm = 1880 μg/m^3	1 μg/m^3 = 0.532 ppm
ozone	1 ppm = 2000 μg/m^3	1 μg/m^3 = 0.500 ppm
peroxyacetyl nitrate	1 ppm = 5000 μg/m^3	1 μg/m^3 = 0.200 ppm

1 Torr = 1.333×10^2 pascals = 1 mmHg

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[a] All conversion factors for atmospheric pollutants refer to 25°C and 101 kPa (1 atm) pressure.

1. SUMMARY AND RECOMMENDATIONS FOR FURTHER STUDIES

1.1 Summary

1.1.1 Properties and analytical methods

Carbon monoxide (CO) is a colourless, odourless, tasteless gas that is slightly less dense than air. It is a product of incomplete combustion of carbon-containing fuels and is also produced by some industrial and biological processes. Its health significance as a contaminant of air is largely due to the fact that it forms a strong coordination bond with the iron atom of the protohaem complex in haemoglobin forming carboxyhaemoglobin (HbCO) and thus impairs the oxygen-carrying capacity of the blood. The dissociation of oxyhaemoglobin is also altered by the presence in blood of carboxyhaemoglobin so that the supply of oxygen to tissues is further impaired. The affinity of haemoglobin for carbon monoxide is roughly 240 times that of its affinity for oxygen; the proportions of carboxyhaemoglobin and oxyhaemoglobin in blood are largely dependent on the partial pressures of carbon monoxide and oxygen. Carbon monoxide is absorbed through the lungs and the concentration[a] of carboxyhaemoglobin in the blood at any time will depend on several factors. When in equilibrium with ambient air, the carboxyhaemoglobin content of the blood will depend mainly on the concentrations of inspired carbon monoxide and oxygen. However, if equilibrium has not been achieved, the carboxyhaemoglobin concentration will also depend on the time of exposure, pulmonary ventilation, and the carboxyhaemoglobin originally present before inhalation of the contaminated air. Formulae exist by which these estimates can be made. In addition to its reaction with haemoglobin, carbon monoxide combines with myoglobin, cytochromes, and some enzymes; the health significance of these reactions is not clearly understood but is likely to be of less importance than that of the reaction of the gas with haemoglobin.

Methods available for the measurement of carbon monoxide in ambient air[b] range from fully automated methods using the non-dispersive infrared technique and gas chromatography to very simple semiquantitative manual methods using detector tubes. Since the formation of carboxyhaemoglobin in man is dependent on many factors

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[a] Throughout the document, the word concentration refers to mass concentration, unless otherwise stated.

[b] Selected Methods of Measuring Air Pollutants, WHO Offset

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including the variability of ambient air concentrations of carbon monoxide, carboxyhaemoglobin concentrations should be measured rather than calculated. Several relatively simple methods are available for determining carbon monoxide either by analysis of the blood or of alveolar air that is in equilibrium with the blood. Some of these methods have been validated by careful comparative studies.

1.1.2 Sources of environmental pollution

At present, the significance of natural sources of carbon monoxide for man is uncertain. Estimates of man-made carbon monoxide emissions vary from 350 to 600 million tonnes per annum. By far the most important source of carbon monoxide at breathing level is the exhaust of petrol-powered motor vehicles. The emission rate depends on the type of vehicle, its speed, and its mode of operation. Other sources include heat and power generators, some industrial processes such as the carbonization of fuel, and the incineration of refuse. Faulty domestic cooking and heating appliances may be important sources that are often overlooked.

1.1.3 Environmental levels

Natural background levels of carbon monoxide are low (0.01-0.9 mg/m^3 or 0.01-0.8 ppm). Carbon monoxide concentrations in urban areas are closely related to motor traffic density and to weather and vary greatly with time and distance from the sources. The configuration of buildings is important and concentrations fall sharply with increasing distance from the street.

There are usually well-marked diurnal patterns with peaks corresponding to the morning and evening "rush hours". Data from Japan and the USA show that 8-h mean concentrations of carbon monoxide are generally less than 20 mg/m^3 (17 ppm). However, maximum 8-h mean concentrations of up to 60 mg/m^3 (53 ppm) have occasionally been recorded. Much higher relatively transient peaks may be observed in still weather where there is traffic congestion, and high concentrations can be found in confined spaces such as tunnels, garages, and loading bays in which vehicles operate and in vehicles with faulty exhaust systems. There may be relatively high pollution by carbon monoxide in workplaces and in some homes with cooking and heating appliances that are faulty or do not have flues.

By far the commonest cause of high carboxyhaemoglobin