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BASIS FOR ESTABLISHING GUIDES FOR SHORT-TERM EXPOSURES OF THE PUBLIC TO AIR POLLUTANTS

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13. ABSTRACT

This report was presented at the Proceedings of the 2nd Annual Conference on Environmental Toxicology, sponsored by the SysteMed Corporation and held in Fairborn, Ohio on 31 August, 1 and 2 September 1971. Major technical areas discussed included toxicological evaluation of volatile halogenated compounds, protection of the public against air pollution and toxicological problems with aircraft, missiles, and space vehicles.

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PAPER NO. 15

BASIS FOR ESTABLISHING GUIDES FOR SHORT-TERM EXPOSURES OF THE PUBLIC TO AIR POLLUTANTS*

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This paper and the one by Dr. Favorite are being presented on behalf of the Committee on Toxicology of the National Academy of Sciences - National Research Council. The chairman of the Committee, Dr. Herbert E. Stokinger, was unable to attend this year's conference and has asked us to provide a summary of recent and current work of the Committee on short-term exposures of the public to air pollutants.

Before proceeding with the discussion a quick history and orientation will be helpful for your understanding and perspective on the subject. One of the primary functions of the National Academy of Sciences is to serve as an independent source of scientific and technical consultation to the federal government. The National Research Council is the organizational unit providing most of these services. It does so through a series of committees whose membership is drawn from the entire scientific community of the U.S. These members serve out of a sense of professional and patriotic duty. They receive no fees for their services, but are reimbursed for their travel and other out-of-pocket expenses. One of these committees is the Committee on Toxicology whose membership is shown on table I.

*Prepared under Contract No. CPA 70-57 between the National Academy of Sciences, Advisory Center on Toxicology and the Air Pollution Control Office of the Environmental Protection Agency.

The Advisory Center on Toxicology is a full-time, paid-staff unit in the National Research Council whose task is to provide technical and logistic service to the Committee on Toxicology and to maintain liaison with the nine supporting federal agencies. Our technical support of the Committee consists primarily of a toxicology information storage and retrieval program.

TABLE I

COMMITTEE ON TOXICOLOGY
OF THE
NATIONAL ACADEMY OF SCIENCES - NATIONAL RESEARCH COUNCIL
1971 - 1972

HERBERT E. STOKINGER, CHAIRMAN

ARTHUR B. DUBOIS, VICE CHAIRMAN

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The passage of the first Clean Air Act a few years ago enabled the health oriented staff of the sponsoring agencies to expand their concerns for the occupational environment to the public environment. This led to requests for acceptable levels corresponding to the occupational TLV's and EEL's that could be applied to exposures of the public to air contaminants. In order to respond to these requests, Dr. John Middleton as head of the National Air Pollution Control Administration invited the Committee on Toxicology to recommend, where possible, air quality standards for short-term exposures. This led to a contract with what is now the Air Programs Office of the Environmental Protection Agency and it is a pleasure to acknowledge their financial support under contract No. CPA 70-57.

Under the terms of this contract the Committee was to develop four documents. One of these was to be a set of specifications, or procedures, or definitions of what should be considered when recommending short-term air quality standards. This document is titled "Basis for Establishing Guides for Short-Term Exposures of the Public to Air Pollutants." The other three documents are identified as "Guides for Short-Term Exposures of the Public to Air Pollutants" and they deal with oxides of nitrogen, hydrogen chloride, and hydrogen fluoride. The present paper will describe the "Basis" document and Dr. Favorite's paper will describe the "Guides."

Short-term exposures are a separate and distinctly different health problem from that of chronic ambient air pollution. The effects of brief exposures to relatively high concentrations of air pollutants may be qualitatively and quantitatively different from those of chronic or frequently repeated exposures.

A short-term exposure to an air pollutant is defined as exposure experienced by an individual to a pollutant released from a single source for a brief time. The duration of such an exposure may be as much as 60 minutes under favorable atmospheric conditions. Under stagnant atmospheric conditions the short-term exposure may last up to 24 hours. There is little practical significance in considering exposures for less than 10 minutes, since variations in the dynamic processes of air movement and mixing lead to considerable uncertainty in predicting the amount of pollutant that might be inhaled. Short-term Guides are thus directed at relatavely brief exposures to relatively high concentrations. They will be in addition to ambient levels of pollution existing at the time. They will involve a discrete downwind area and will affect only limited portions of the population in the vicinity of the source.

The Committee considered two categories of short-term exposures: those predictable as to time and place of occurrence; and those that are unpredictable. For predictable exposures the Committee endeavors to recommend Short-Term Public Limits (STPL's) which are concentrations whose effect upon public health and welfare will be no greater than is acceptable under prevailing criteria and standards for ambient air quality. For unpredictable exposures the Committee will try to recommend Public Emergency Limits (PEL's) which will be expected to produce minor but fully reversible injury among those exposed.

The Committee recognizes that while its attention must be primarily on human health there must also be secondary consideration to the effects of the short-term pollution episodes on plants, animals, and materials. In some cases these targets may be more sensitive than humans and thus require different criteria or standards.

Undesirable esthetic effects such as unpleasant odors or reduced scenic visibility, and associated economic losses, should be considered in connection with predictable exposures. They are not deemed to be important factors in standards to be applied to short-term unpredictable exposures.

The maintenance and monitoring of air-quality standards requires that suitable methods be available for sampling and analyzing air for the pollutant in question. If adequate procedures are not available the immediate need for research and development should be emphasized. Recommendations for "zero" levels are technically meaningless. If it is desirable to control a material to the lowest possible level, a phrase should be used such as "nondetectable by the most sensitive method of analysis available."

The physical form of a pollutant, i.e., gas, vapor, dust, or mist, may have a pronounced effect upon the route and extent of its attack. Particles up to 10 micra in diameter can be inhaled into the lungs, whereas larger particles are filtered out in the upper respiratory passages. Such properties as solubility and chemical composition will also alter the nature and degree of the effect of a pollutant. Consequently, it is essential that the pollutant be well characterized.

Exposure of the public to atmospheric pollutants is seldom, if ever, to a single compound. The effects of any pollutant involved in a short-term episode may be modified by interaction with one or more ambient pollutants. The interaction may be physical, as in the case of adsorption of gases on solid particulates; it may be chemical, as in photochemical smog; it may be biological, where the toxic effects are modified either in degree or in nature, as in thickening of the alveolar barrier by NO_2. It is, therefore, important that information be obtained on the composition of the ambient air at the anticipated site of the short-term exposure.

As far as is known, all living systems have some ability to withstand injury from toxic materials. This resistance may be due to mechanisms that prevent absorption of the toxicant, rapidly excrete it, metabolize and detoxify it, or increase the rate of repair of injured tissues. These mechanisms are sometimes inherent in the organism and are sometimes enhanced or acquired in response to toxic stress. Whenever the capacity of these protective mechanisms is exceeded by the applied toxic stress the effect will become observable. Beyond this point of no biologically significant effect from a finite dose, the extent of the effect, i.e., the degree of injury, will increase with an increasing dosage of toxicant, with death of the organism as the upper limit. The relationship between causative dosage and resultant effect is not necessarily a constant proportionality over the entire range. This lack of proportionality in dose-effect relationships makes extrapolations much beyond the range of available data unreliable.

Most of the reliable data on the toxicity of any material are the results of carefully controlled experiments on animals. Occasionally, data may be available on controlled exposures of human volunteers. Comprehensive epidemiological data can only rarely be found.

The use of data from animal testing for predicting the effects of a substance on humans carries with it several sources of uncertainty which include

1. differences between individuals of the same animal species
2. differences between animal species
3. extrapolation of the data from animals to humans
4. differences between humans
5. nonuniformity of the contaminated air mass
6. deviations from the predicted movement of the contaminated air mass.

The Committee has spelled out in some detail the kinds of data it would like to have as a basis for its recommendations of short-term limits. These needs may be summarized as follows:

1. the most sensitive target organ(s) or body system(s) to be affected by the short-term air contaminant
2. a full characterization of the nature of the effect upon the target(s)
3. the range of the time-concentration relationship for the target(s) from no effect to severe effects

4. the rate of recovery from reversible effects

5. the nature and severity of injury at which the effect ceases to be reversible

6. identification of cumulative effects, if any

7. the combined effects, if any, of the toxicant with other air pollutants and the concentrations at which the combined effects occur.

8. identification of types of functional abnormalities and pathological states among the potentially exposed population which may render such individuals more susceptible to the pollutant.

Even with these kinds of data, interpretation requires mature, experienced, scientific judgment from a variety of professional disciplines. The evaluation should consider the conditions under which the data were obtained and, in particular, their relevance to the conditions of human exposure. How closely do the test species and the target organ compare in morphology, sensitivity of response, and metabolism with that of man? Were the observed animal responses the consequences of exposure conditions to which the public may be subjected?

Having resolved these questions to the best of its ability the Committee must then develop its recommended limits. Looking at the situation realistically there will be many remaining valid sources of doubt or uncertainty so that resort must be made to the incorporation of safety factors. These safety factors should be of a magnitude commensurate with (1) the severity of the response; (2) degree of hypersusceptibility related to (a) preexisting disease, such as respiratory disease, (b)heredity, (c) nutritional state, or (d) age; (3) extent of physical exertion; and (4) uniqueness of man's response, e.g., hypersensitivity of the respiratory tract.

At this point the recommendations for STPL's and PEL's have been reached and the Committee has gone as far as it can. However, before these can be promulgated as standards it is my opinion that the Administrator of EPA and his staff must consider the impact of these limits on all aspects of the public interest. Selecting an upper limit for the concentration of an air pollutant for a short-term exposure of the public entails a choice of the least risk to the public health of all the risks to the public associated with the operation releasing the pollutant. It thus involves a study not only of the effects such as those already described but also an equally careful review of the source of the pollutant and the reasons for its presence. For example, consider the testing of a new firefighting technique or the training of firemen. The extent of public exposure to smoke, the firefighting agent, and its pyrolysis products are predictable. Among the risks to be evaluated and balanced would be the health and other effects that are the subject of these Guides, and the risk to the public of being deprived of adequate fire protection. There is no justification, in the view of the Committee, for subjecting the public to any appreciable health risk for a predictable exposure. Appropriate controls and safeguards must be developed.

The risks associated with unpredictable exposures [illegible] for their full evaluation a consideration of the probability of an accident. Such risks can never be reduced absolutely to zero but, by proper planning of operations and equipment design, they can be minimized. Exposure to an accidental release of an air pollutant should be a rare event in the lifetime of any individual. In some instances activities may be sufficiently important to justify accepting some probability of an accident associated with some degree of risk of reversible effects from exposure to a pollutant. There should be no acceptance of any possibility of irreversible injury from accidental exposure to a pollutant.