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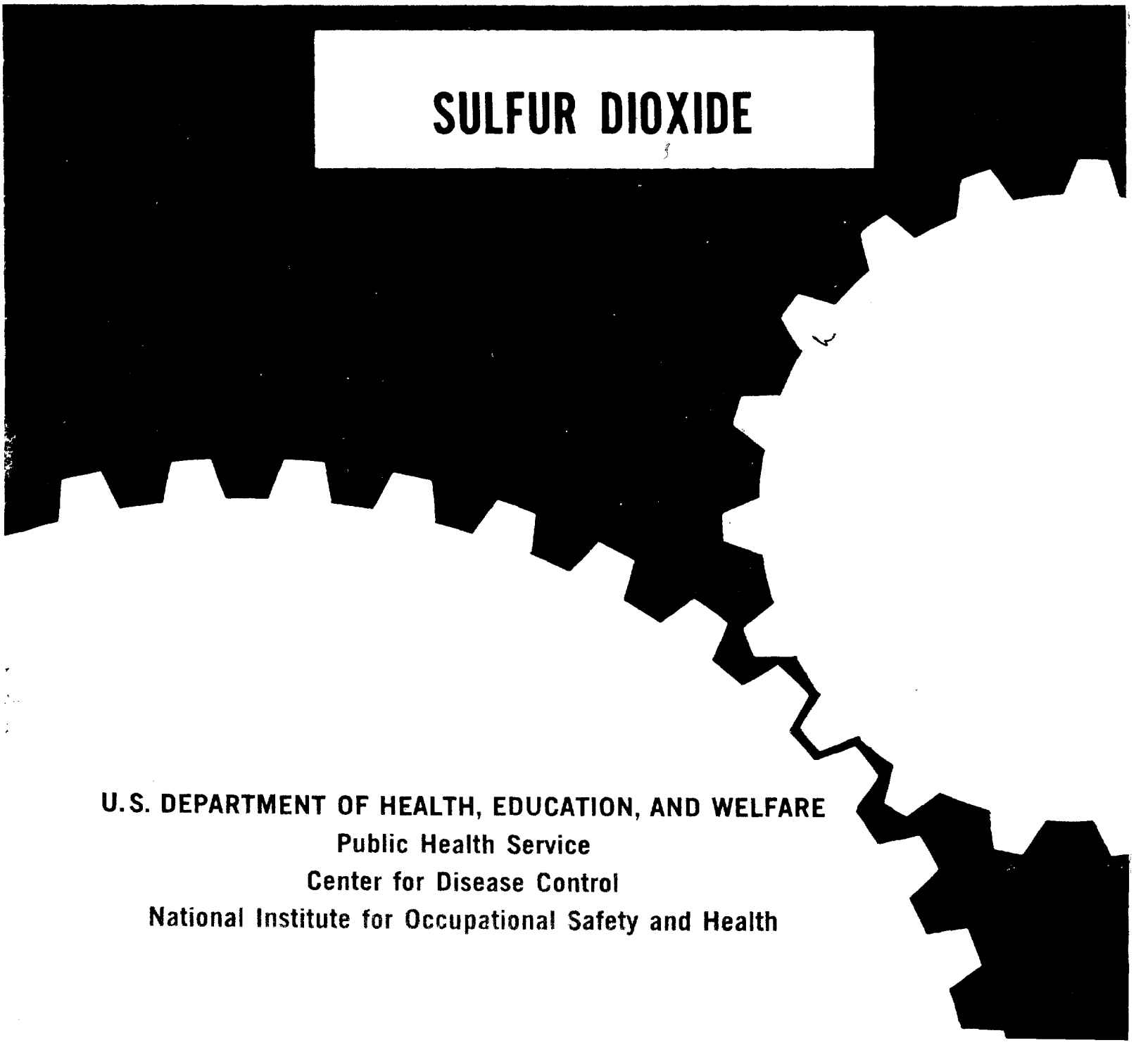
OCCUPATIONAL EXPOSURE TO

SULFUR DIOXIDE



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

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OCCUPATIONAL EXPOSURE TO SULFUR DIOXIDE

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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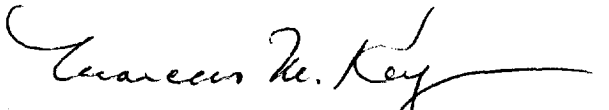
National Institute for Occupational Safety and Health
1974

PREFACE

The Occupational Safety and Health Act of 1970 emphasizes the need for standards to protect the health and safety of workers exposed to an ever-increasing number of potential hazards at their workplace. To provide relevant data from which valid criteria and effective standards can be deduced, the National Institute for Occupational Safety and Health has projected a formal system of research, with priorities determined on the basis of specified indices.

It is intended to present successive reports as research and epidemiologic studies are completed and sampling and analytical methods are developed. Criteria and standards will be reviewed periodically to ensure continuing protection of the worker.

I am pleased to acknowledge the contributions to this report on sulfur dioxide by members of my staff, the valuable and constructive comments presented by the Review Consultants on Sulfur Dioxide, the ad hoc committees of the American Academy of Occupational Medicine and the American Conference of Governmental Industrial Hygienists, by Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine, and by William A. Burgess, NIOSH consultant on respiratory protection. The NIOSH recommendations for standards are not necessarily a consensus of all the consultants and professional societies that reviewed this criteria document on sulfur dioxide. Lists of the NIOSH Review Committee members and of the Review Consultants appear on the following pages.



Marcus M. Key, M.D.
Director, National Institute
for Occupational Safety and Health

The Office of Research and Standards Development, National Institute for Occupational Safety and Health, had primary responsibility for development of the criteria and recommended standard for sulfur dioxide. Tabershaw-Cooper Associates, Inc., developed the basic information for consideration by NIOSH staff and consultants under contract No. HSM-99-72-116. Douglas L. Smith, Ph.D., served as criteria manager and had NIOSH program responsibility for development of the document.

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CRITERIA DOCUMENT: RECOMMENDATIONS FOR AN OCCUPATIONAL EXPOSURE STANDARD FOR SULFUR DIOXIDE

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I. RECOMMENDATIONS FOR A SULFUR DIOXIDE STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that worker exposure to sulfur dioxide (SO2) in the workplace be controlled by adherence to the following sections. The standard is designed to protect the health and safety of workers for an 8-hour day, 40-hour work week over a working lifetime; compliance with the standard should therefore prevent adverse effects of sulfur dioxide on the health and safety of workers. The standard is measurable by techniques that are valid, reproducible, and available to industry and government agencies. Sufficient technology exists to permit compliance with the recommended standard. The standard will be subject to review and will be revised as necessary.

"Exposure to sulfur dioxide" means exposure to a concentration of sulfur dioxide equal to or above one-half the recommended workroom environmental standard. Exposures at lower environmental concentrations will not require adherence to the following sections. Procedures for identification of exposure areas can be accomplished by time-weighted average (TWA) determinations by methods described in Appendices I and II or by any method shown to be equivalent in accuracy, precision, and sensitivity to the methods specified.

If "exposure" to other chemicals also occurs, for example from arsenic, then provisions of any applicable standard for the other chemicals shall also be followed.

Section 1 - Environmental (Workplace Air)

(a) Concentration

Occupational exposure to sulfur dioxide shall be controlled so that workers shall not be exposed to sulfur dioxide at a concentration greater than 2 parts per million parts of air (5 milligrams per cubic meter of air) determined as a time-weighted average exposure for an 8-hour work day.

(b) Sampling, Calibration, and Analysis

Procedures for sampling, calibration of equipment, and analysis of environmental samples shall be as provided in Appendix I or by any method shown to be equivalent in accuracy, precision, and sensitivity to the method specified.

Section 2 - Medical

(a) Comprehensive preplacement and annual medical examinations shall be provided for all workers subject to "exposure to sulfur dioxide." The examination shall be directed toward but not limited to the eyes and the cardiopulmonary system; particular attention shall be focused on complaints of mucous membrane irritation and cough. An evaluation of the advisability of a worker's using negative- or positive-pressure respirators shall also be made.

(b) Initial examinations for presently employed workers shall be offered within 6 months of the promulgation of a standard incorporating these recommendations and annually thereafter.

(c) The medical representatives of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, and of the employer shall have access to all medical records. Physicians designated and authorized by any employee or former employee shall have access to his medical records.

(d) Medical records shall be maintained for persons employed one or more years in work involving exposure to sulfur dioxide. X-rays for the 5 years preceding termination of employment and all medical records with pertinent supporting documents shall be maintained at least 20 years after the individual's employment is terminated.

Section 3 - Labeling (Posting)

(a) Labeling

Cylinders and other containers of sulfur dioxide shall bear the following label in addition to or in combination with labels required by other statutes, regulations, or ordinances:

SULFUR DIOXIDE

Warning! Extremely irritating gas

and liquid under pressure.

Liquid causes burns.

Avoid breathing gas.

(b) Posting

The following warning sign shall be affixed in a readily visible location at or near entrances to areas in which there is occupational exposure to sulfur dioxide:

SULFUR DIOXIDE

Warning! Potential exposure to irritating gas.
Avoid unnecessary exposure to concentrations
producing irritation or coughing.

This warning sign shall be printed both in English and in the predominant primary language of non-English-speaking workers, if any.

Section 4 - Personal Protective Equipment and Work Clothing

Subsection (a) shall apply whenever a variance from the standard recommended in Section 1 is granted under provisions of the Occupational Safety and Health Act, or in the interim period during the application for a variance. When the limits of exposure to sulfur dioxide prescribed in subsection (a) of Section 1 cannot be met by controlling the concentration of sulfur dioxide in the work environment, an employer must utilize, as provided in subsection (a) of this Section, a program of respiratory protection to effect the required protection of every worker exposed.

(a) Respiratory Protection

Engineering controls shall be used wherever feasible to maintain sulfur dioxide concentrations below the prescribed limit. Appropriate respirators shall be provided and used when a variance has been granted to allow respirators as a means of control of exposure to routine operations and while the application is pending. Administrative controls should also be used to reduce exposure. Respirators shall also be provided and used for nonroutine operations (occasional brief exposures above the TWA of 2 ppm and for emergencies); however, for these instances a variance is not required but the requirements set forth below continue to apply. Appropriate respirators as described in Table I-1 shall only be used pursuant to the following requirements:

(1) For the purpose of determining the type of respirator to be used, the employer shall measure the atmospheric concentration of sulfur dioxide in the workplace when the initial application for variance is made and thereafter whenever process, worksite, climate, or control changes occur which are likely to increase the sulfur dioxide concentration. This requirement shall not apply when only atmosphere-supplying positive pressure respirators are used. The employer shall ensure that no worker is being exposed to sulfur dioxide in excess of the standard either because of improper respirator selection, fit, use, or maintenance.

(2) The respirator and cartridge or canister used shall be of the appropriate class, as determined on the basis of exposure to sulfur dioxide gas.

(3) A respiratory protective program meeting the general requirements outlined in Section 3.5 of American National Standard Practices for Respiratory Protection Z88.2-1969 shall be established and enforced by the employer. In addition, Sections 3.6 (Program Administration), 3.7 (Medical Limitations), and 3.8 (Approval) shall be adopted and enforced.

(4) The employer shall provide respirators in accordance with Table I-1 below and shall ensure that the employee uses the respirator provided.

(5) Respiratory protective devices described in Table I-1 shall be those approved under provisions of 30 CFR 11 published in the Federal Register, volume 37, page 6244, dated March 25, 1972.

(6) Respirators specified for use in higher concentrations of sulfur dioxide are permitted in atmospheres of lower concentrations.

(7) Employees shall be given instruction on the use of respirators assigned to them, cleaning of the respirators, and how to test for leakage.

(8) Wherever bulk sulfur dioxide is handled, emergency and escape-type respirators shall be made readily available for each worker.

TABLE I-1

REQUIREMENTS FOR RESPIRATOR USAGE

Multiples of TWA Limit	Respirator Type
Less than or equal to 10x	(1) Chemical cartridge respirator for sulfur dioxide with quarter, half, or full facepiece.
	(2) Type C supplied air respirator, demand type (negative pressure), with quarter or half mask facepiece.
Less than or equal to 100x	(1) Gas mask with chin style canister for acid gases.
	(2) Gas mask with front or back mounted chest type canister for acid gases.
	(3) Type C supplied air respirator, demand (negative pressure); pressure-demand; or continuous flow type with full facepiece.
	(4) Self-contained breathing apparatus in demand mode (negative pressure) with full facepiece.
Greater than 100x	(1) Self-contained breathing apparatus in pressure-demand mode (positive pressure).
	(2) Combination supplied air respirator, pressure-demand type, with auxiliary self-contained air supply.
Emergency (No concentration limit)	(1) Self-contained breathing apparatus in pressure-demand mode (positive pressure).
	(2) Combination supplied air respirator, pressure-demand type, with auxiliary self-contained air supply.
Evacuation or escape (No concentration limit)	(1) Self-contained breathing apparatus in demand or pressure-demand mode (negative or positive pressure).
	(2) Gas mask with acid gas chest canister, and mouthpiece respirator.

(b) Eye Protection

(1) The American National Standard Practice for Occupational and Educational Eye and Face Protection, ANSI Z87.1-1968, shall be employed.

(2) Chemical safety goggles-- cup-type or rubber-framed goggles, equipped with approved impact-resistant glass or plastic lenses, shall be worn whenever there is danger of eye contact, such as working with pipelines, valves, etc, which might leak and spurt liquid sulfur dioxide.

(3) Spectacle-type safety goggles-- metal or plastic rim safety spectacles with unperforated side shields, or suitable all-plastic safety goggles may be used where continuous eye protection is desirable. If use of this type of eye protection is mandatory, prescription lenses shall be provided for those employees who need them.

(4) Face shield-- plastic shields with forehead protection may be worn in place of or in addition to goggles.

(c) Work Clothing

(1) Work clothing should be changed at least twice a week or more frequently if required.

(2) Sulfur dioxide-wetted clothing, unless impervious, shall be removed promptly.

Section 5 - Apprisal of Employees of Hazards from Sulfur Dioxide

At the beginning of employment in a sulfur dioxide area, employees exposed to sulfur dioxide shall be informed of all hazards, relevant

symptoms of overexposure, appropriate emergency procedures, and proper conditions and precautions for safe use or exposure. Instruction shall include, as a minimum, all information in Appendix III which is applicable to sulfur dioxide. The information shall be posted in the work area and kept on file and readily accessible to the worker at all places of employment where sulfur dioxide is involved in unit processes and operations or is released as a product, byproduct, or contaminant.

A continuing educational program shall be instituted to ensure that all workers have current knowledge of job hazards, proper maintenance procedures and cleanup methods, and that they know how to correctly use respiratory protective equipment and protective clothing.

Information as required shall be recorded on US Department of Labor Form OSHA-20 "Material Safety Data Sheet" or a similar form approved by the Occupational Safety and Health Administration, US Department of Labor.

Section 6 - Work Practices

(a) Storage and Handling

(1) Because sulfur dioxide vaporizes at atmospheric pressure and temperature, it must be stored in gas tight containers under pressure and at temperatures which should not reach 54 C (130 F). Sulfur dioxide is not flammable and, when dry, is not corrosive to ordinary metals.

(2) Each container of sulfur dioxide shall be examined for leaks upon its arrival or upon filling and shall be reexamined periodically at least every 3 months.

(3) Prior to transferring sulfur dioxide from a storage container, an inspection shall be conducted to detect any gas leaks in the transport system (eg, cylinder seal with gas regulator, regulator apparatus, regulator seal with transport conduits, conduit system, etc).

(4) Cylinders of sulfur dioxide shall be secured so they cannot be damaged during transport or use.

(b) Emergency Procedures

(1) Procedures for emergencies shall be established to meet foreseeable events. The irritant and choking properties of sulfur dioxide provide warning of overexposure and evacuation from the area should begin as soon as possible.

(2) Appropriate respirators shall be available for wear during evacuation.

(3) Where there is the possibility of sulfur dioxide contact on the eyes or skin, drench-type showers, eye-wash fountains, and cleansing facilities should be installed and maintained to provide prompt, immediate access by the workers.

(c) Exhaust Systems and Enclosure

Exhaust ventilation and enclosure processes shall be used wherever practicable to control workplace concentrations. Systems shall be designed and maintained to prevent the accumulation or recirculation of sulfur

dioxide into the workroom. In addition, necessary measures shall be taken to ensure that discharge outdoors will not produce a health hazard to humans, animals, or plants.

(d) General Housekeeping

Emphasis shall be placed upon cleanup, inspection and repair of equipment and leaks, and proper storage of materials.

Section 7 - Monitoring and Reporting Requirements

Workroom areas where it has been determined, on the basis of an industrial hygiene survey or the judgment of a compliance officer, that environmental levels do not exceed one-half the environmental standard shall not be considered to have sulfur dioxide exposure. Records of these surveys, including the basis for concluding that air levels are below one-half the environmental standard, shall be maintained until a new survey is conducted. Surveys shall be repeated when any process change indicates a need for reevaluation or at the discretion of the compliance officer. Requirements set forth below apply to areas in which there is sulfur dioxide exposure.

Employers shall maintain records of environmental exposures to sulfur dioxide based upon the following sampling and recording schedules:

(a) In all monitoring, samples representative of the exposure in the breathing zone of employees shall be collected. An adequate number of samples shall be collected to permit construction of a time-weighted average (TWA) exposure for every operation or process. The minimum number

of representative TWA determinations for an operation or process shall be based on the number of workers exposed as provided in Table I-2.

(b) The first environmental sampling shall be completed within 6 months of the promulgation of a standard incorporating these recommendations.

(c) Environmental samples shall be taken within 30 days after installation of a new process or process changes.

(d) Samples shall be collected at least quarterly in accordance with Appendix I for the evaluation of the work environment with respect to the recommended standard.

(e) Environmental monitoring of an operation or process shall be repeated at 15-day intervals when sulfur dioxide concentration has been found to exceed the recommended environmental standard. In such cases suitable controls shall be initiated and monitoring shall continue at 15-day intervals until two consecutive surveys indicate the adequacy of these controls.

(f) Records of all sampling and of medical examinations shall be maintained for at least 20 years after the individual's employment is terminated. Records shall indicate the type of personal protection devices, if any, in use at the time of sampling. Records shall be maintained so that they can be classified by employee. Each employee shall be able to obtain information on his own environmental exposure.

TABLE I-2

SAMPLING SCHEDULE

Number of Employees Exposed	Number of TWA Determinations
1-20	50% of the total number of workers
21-100	10 plus 25% of the excess over 20 workers
over 100	30 plus 5% of the excess over 100 workers

II. INTRODUCTION

This report presents the criteria and the recommended standard based thereon which were prepared to meet the need for preventing occupational diseases arising from exposure to sulfur dioxide. The criteria document fulfills the responsibility of the Secretary of Health, Education, and Welfare, under Section 20(a)(3) of the Occupational Safety and Health Act of 1970 to "...develop criteria dealing with toxic materials and harmful physical agents and substances which will describe... exposure levels at which no employee will suffer impaired health or functional capacities or diminished life expectancy as a result of his work experience."

The National Institute for Occupational Safety and Health (NIOSH), after a review of data and consultations with others, formalized a system for the development of criteria upon which standards can be established to protect the health of workers from exposure to hazardous chemical and physical agents. It should be pointed out that any recommended criteria for a standard should enable management and labor to develop better engineering controls resulting in more healthful work practices and should not be used as a final goal.

These criteria for a standard for sulfur dioxide are part of a continuing series of criteria developed by NIOSH. The proposed standard applies only to the processing, manufacture, and use of sulfur dioxide, or its release as an intermediate, byproduct, or impurity therefrom as applicable under the Occupational Safety and Health Act of 1970.

These criteria were developed to ensure that the standard based thereon would (1) protect against development of acute and chronic sulfur dioxide poisoning, (2) be measurable by techniques that are valid, reproducible, and available to industry and governmental agencies, and (3) be attainable with existing technology.

Sulfur dioxide is a rather common hazard of the workplace and an important component of the community air pollution problem. It is a primary constituent of certain processes and may enter the working environment either as a byproduct or as an impurity in a fuel or some raw material being processed.

These criteria were not designed for the population-at-large and any extrapolation beyond general occupational exposures is not warranted.