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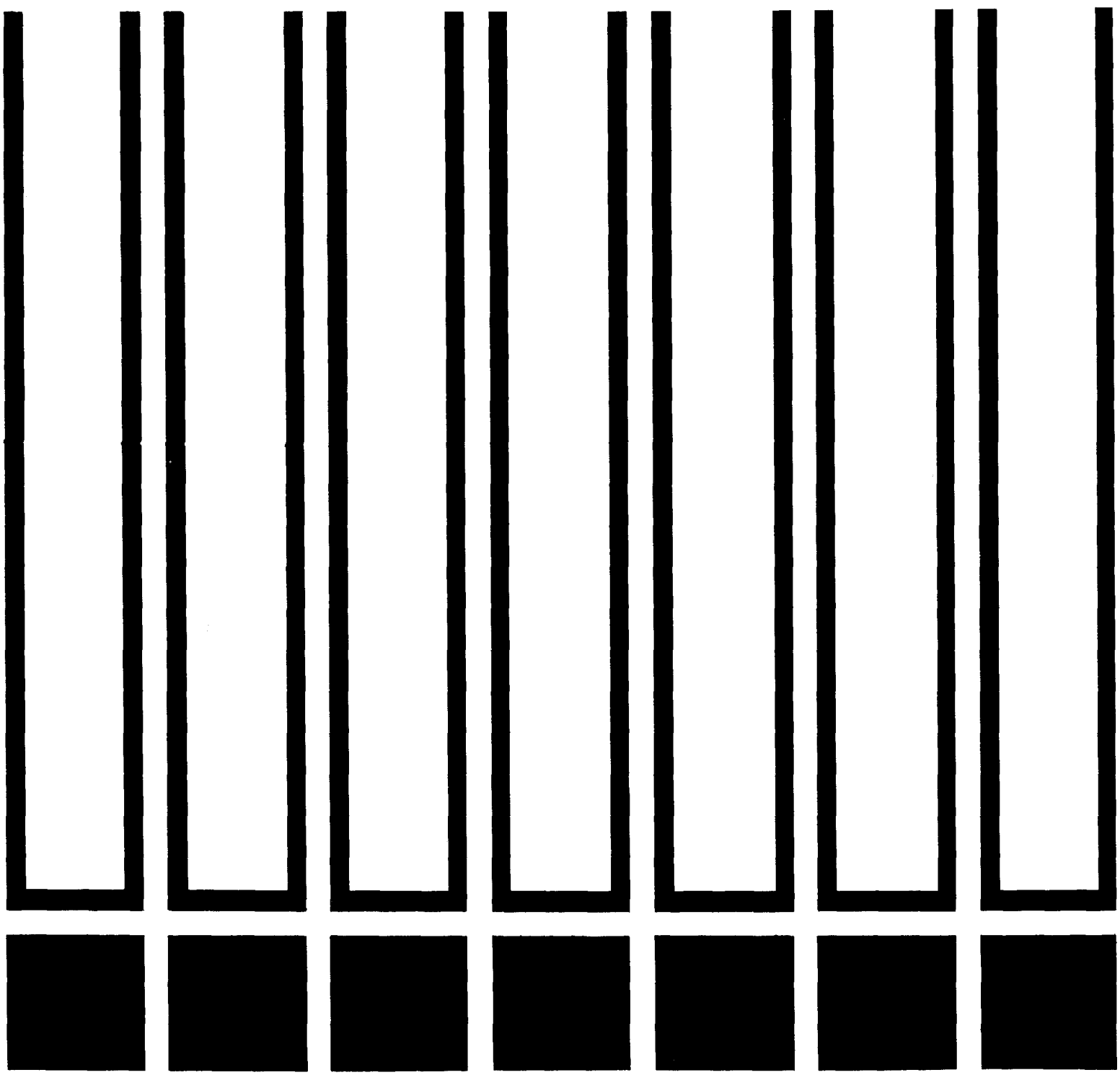

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service / Center for Disease Control

National Institute for Occupational Safety and Health

criteria for a recommended standard....

OCCUPATIONAL EXPOSURE TO CADMIUM

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National Institute for Occupational Safety and Health

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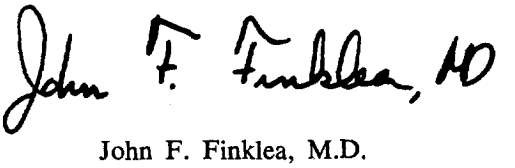
PREFACE

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. The National Institute for Occupational Safety and Health has projected a formal system of research, with priorities determined on the basis of specified indices, to provide relevant data from which valid criteria for effective standards can be derived. Recommended standards for occupational exposure, which are the result of this work, are based on the health effects of exposure. The Secretary of Labor will weigh these recommendations along with other considerations such as feasibility and means of implementation in developing regulatory standards.

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 cadmium by members of my staff, by the Review Consultants on Cadmium, by the ad hoc committees of the American Industrial Hygiene Association and of the Society of Toxicology, by Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine, and by Edwin C. Hyatt on work practices and 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 cadmium. Lists of the NIOSH Review Committee members and of the Review Consultants appear on the following pages.



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The Division of Criteria Documentation and Standards Development, National Institute for Occupational Safety and Health, had primary responsibility for development of the criteria and recommended standard for cadmium. The Division review staff consisted of J. Henry Wills, Ph.D. (Chairman) and Frank L. Mitchell, D.O., with Philip J. Bierbaum (Division of Surveillance, Hazard Evaluations, and Field Studies) and Robert L. Roudabush, Ph.D.

The University of Cincinnati, College of Medicine, developed the basic information for consideration by NIOSH staff and consultants under contract No. HSM-99-72-87. Keith H. Jacobson, Ph.D., had NIOSH program responsibility and served as criteria manager.

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I. RECOMMENDATIONS FOR A CADMIUM STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that worker exposure to cadmium in the workplace be controlled by adherence to the following sections. The standard is designed to protect the health and safety of workers for up to a 10-hour workday, 40-hour week, over a working lifetime. Compliance with all sections of the standard should prevent adverse effects of exposure to cadmium 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 criteria and the standard will be subject to review and revision as necessary.

"Cadmium" refers to elemental cadmium and all cadmium compounds. An "action level" is defined as half the time-weighted average concentration environmental limit of cadmium. "Occupational exposure to cadmium" is defined as exposure to cadmium at a concentration greater than the action level. Exposures at lower environmental concentrations will not require adherence to the following sections, except for Section 6(b) and 7(d).

Section 1—Environmental (Workplace Air)

(a) Concentration

Occupational exposure to cadmium shall be controlled so that workers are not exposed to cadmium at a concentration greater than 40 micrograms per cubic meter of air (40 μg Cd/cu m) determined as a time-weighted average (TWA) exposure concentration for up to a 10-hour workday, 40-hour workweek, or at a ceiling concentration greater than 200 μg Cd/cu m for any 15-minute sampling period.

(b) Sampling and analysis

Sampling in the work environment shall be performed by the method provided in Appendix I or by a method with at least equivalent efficiency. Samples shall be analyzed by the method provided in Appendix II or by a method shown to be at least equivalent in precision and sensitivity.

Section 2—Medical

Medical monitoring shall be made available to all workers subject to occupational exposure to cadmium.

(a) Preplacement examinations shall be made available to new or reassigned employees prior to job placement, and, within 6 months of the promulgation of a standard based on these recommendations, to employees already engaged in work involving exposure to cadmium.

Preplacement examinations shall include comprehensive work and medical histories, a 14" X 17" P.A. chest X-ray, measurement of forced vital capacity (FVC) and forced expiratory volume during the first second (FEV_1), measurement of blood pressure, blood analysis (blood urea nitrogen, complete blood count, and serum glutamic oxaloacetate transaminase or other liver enzymes), and urinalysis (microscopic examination, sugar determination, quantitative protein determination, and specific gravity measurement). A judgment of the worker's ability to work in positive or negative pressure respirators shall be made.

The method for protein determination in urine shall be quantitative and capable of detecting low molecular weight proteins (see Appendix III). Determination of urine cadmium levels is also recommended.

(b) Periodic examinations shall also be made available. Except for urine protein determinations, which shall be made available every 4 months, these examinations shall be offered yearly, or as otherwise directed by the responsible physician.

These periodic examinations shall include interim work and medical histories, urinalysis (with quantitative protein determinations every 4 months), pulmonary function tests (FVC and

FEV_1), and blood pressure. Chest radiographs shall be taken if judged necessary by the responsible physician.

In addition, blood analysis, palpation of the prostate in male workers over 40 years old, and monitoring of urine cadmium concentrations are also recommended. If the concentration of cadmium in the urine rises above 10 μg/liter, an investigation of the cause, such as environmental exposures, personal and industrial hygiene practices, and nonoccupational exposure, should be conducted.

Reassessment of occupational exposure, work practices, and personal habits shall be undertaken if FVC or FEV_1 becomes reduced 15% or more or the ratio FEV_1/FVC is reduced 10% or more than would be expected from the age and smoking habits of the person examined, if persistent symptoms of respiratory tract disease develop, if there are frequent upper or lower respiratory infections, or if persistent proteinuria or other abnormal laboratory or clinical findings relatable to cadmium toxicity develop.

Smokers should be counseled on their possibly increased risk of chronic respiratory disease.

(c) At termination of or transfer from employment involving occupational exposure to cadmium, a comprehensive examination including the components of (a) above shall be offered.

(d) Pertinent medical records shall be retained for 20 years after the last occupational exposure to cadmium. These records shall be made available to the designated medical representatives of the Secretary of Labor, of the Secretary of Health, Education, and Welfare, of the employer, and of the employee or former employee.

Section 3—Labeling and Posting

(a) Containers

Shipping and storage containers or packages containing cadmium or cadmium compounds shall bear the following label:

DANGER!

CONTAINS * POISONOUS FUMES MAY BE FORMED ON HEATING HARMFUL IF INHALED OR SWALLOWED AVOID CONTACT WITH SKIN, EYES, AND CLOTHING WASH HANDS THOROUGHLY AFTER HANDLING

Avoid breathing fume, dust, or mist Keep container closed Use only with adequate ventilation

*Complete by inserting "cadmium" or name of cadmium compound.

(b) Work areas

Locations or areas where cadmium dust or fume are likely to be generated shall be designated with clearly visible warning signs as shown below:

DANGER!

CADMIUM (Cd)

Cadmium Fume (or Dust) Areas Authorized Personnel Only Breathing Fume (or Dust) May Cause Immediate or Delayed Injury

No Smoking

Respirators Are Located.....**

**Give location of respirators.

This sign shall be printed in English and in the predominant language of non-English-speaking workers. All employees shall be trained and informed of the hazards and the hazardous areas. All illiterate workers shall receive special attention.

Section 4—Personal Protective Equipment and Clothing

Engineering controls shall be used if needed to maintain airborne cadmium concentrations at or below the limits recommended in Section 1. Compliance with these workplace environmental limits by the use of respirators is permitted only during installation and testing of engineering controls, during performance of nonroutine maintenance or repair, during single operations, or during emergencies. When use of a respirator is permitted, it shall be selected and used in accordance with the following requirements:

(a) For the purpose of determining the type of respirator to be used, the employer shall measure the concentrations of cadmium in the workplace initially and thereafter whenever control, process, operation, worksite, or climate changes occur that are likely to increase the concentration of airborne cadmium.

(b) The employer shall ensure that no worker is exposed to cadmium in excess of the recommended limits because of improper respirator selection, fit, use, or maintenance.

(c) A respiratory protection program meeting the requirements of 29 CFR 1910.134, which incorporates the American National Standard Practices for Respiratory Protection, Z88.2-1969, shall be established and enforced by the employer.

(d) The employer shall provide respirators in accordance with Table I-1, and shall ensure that employees use the respirators provided in a proper manner when wearing of respirators is required.

(e) Respirators selected from those described in Table I-1 shall be those approved under the provisions of 30 CFR 11.

(f) The employer shall ensure that employees are properly instructed in the use of respirators assigned to their use and on how to test for leakage, proper fit, and proper operation.

(g) Respirators specified in Table I-1 for use in atmospheres of higher concentrations of airborne cadmium may be used in atmospheres of lower cadmium concentrations.

(h) The employer shall establish and conduct a program of cleaning, sanitizing, inspecting, maintaining, repairing, and storing of respirators, to ensure that employees are provided with clean respirators that are in good operating condition.

(i) The employer shall periodically monitor the use of respirators to ensure that the proper type of respirator is worn, to evaluate the effectiveness of the respiratory protection program, and to eliminate any deficiencies in use and care of respirators.

Section 5—Informing Employees of Hazards from Cadmium

(a) Workers initially assigned or reassigned to jobs involving occupational exposure to cadmium shall be informed of the hazards, symptoms of overexposure (including information on the characteristics of onset and stages of illness), appropriate procedures to be taken in the event of an emergency, and precautions to ensure safe use and to minimize exposure. They shall be advised of the availability of relevant information, including that prescribed in (c) below. This information shall be accessible to each worker occupationally exposed to cadmium.

(b) A continuing education program, conducted by a person or persons qualified by experience or special training, 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 use respirators correctly. It shall include a description of the general nature of the medical surveillance procedures and why it is advantageous to the worker to undergo these examinations.

(c) Required information shall be recorded on a "Material Safety Data Sheet" as specified in Appendix IV or on any other form approved for the purpose by the Occupational Safety and Health Administration, US Department of Labor.

Section 6—Work Practices

(a) Exhaust Systems

Operations creating workplace exposure to cadmium shall be enclosed to the maximum extent practicable and be provided with local exhaust ventilation unless appropriate air sampling and analysis have demonstrated that concentrations are at or below the environmental limits. Methods other than enclosure and ventilation for meeting exposure limits to cadmium may be used if they bring concentrations in workplace air to or below the environmental limits. Effluent air shall be cleaned to meet any emission standards that may become promulgated. Air from the exhaust ventilation system shall not be recirculated into the workplace.

Enclosures, exhaust hoods, and ductwork shall be kept in good repair so that design airflows are maintained. Airflow shall be measured at each hood at least semiannually, and preferably monthly. Continuous airflow indicators are recommended, such as water or oil manometers properly mounted at the juncture of fume hood and duct throat (marked to indicate acceptable airflow). A log showing design airflow and results of semiannual inspections shall be kept.

(b) Welding, Brazing, and Thermal Cutting

Welding, brazing, or thermal cutting of material containing cadmium shall be performed using local exhaust ventilation demonstrated by air sampling and analysis to keep cadmium concentrations within the limits of Section 1. For single operations where local exhaust ventilation is not available, where air sampling has not been performed,

TABLE I-1

RESPIRATOR SELECTION GUIDE

Cadmium Concentration	Respirator Type
Less than or equal to 0.4 mg/cu m	(1) Half-mask respirator with high-efficiency filter(s). (2) Type C demand-type (negative pressure) supplied-air respirator with half-mask facepiece.
Less than or equal to 2.0 mg/cu m	(1) Full facepiece respirator with high-efficiency filter(s). (2) Type C demand-type (negative pressure) supplied-air respirator with full facepiece. (3) Self-contained breathing apparatus with full facepiece in demand mode (negative pressure).
Less than or equal to 40 mg/cu m	(1) Powered air-purifying (positive pressure) respirator with high efficiency filter(s). (2) Type C continuous-flow (positive pressure) supplied-air respirator.
40 mg/cu m or greater or unknown	(1) Combination supplied-air respirator, pressure-demand type, with auxiliary self-contained air supply. (2) Self-contained breathing apparatus with full facepiece in positive pressure mode.

or where air sampling has demonstrated a likelihood of overexposure to cadmium fume or dust, respirators shall be provided and worn as specified in Section 4.

Where molten cadmium is used or formed, temperatures should be kept as low as possible consistent with the requirements of the operation to prevent excessive fume generation. Additions of cadmium should be made in the manner generating the least fume. Wherever possible, this should be accomplished by automatic controls, with recording of temperature and use of alarms or indicators for higher temperatures.

(c) Emergency Procedures

Emergency procedures shall be established for any event which may result in substantial release of airborne cadmium. Such procedures shall include provision for appropriate respirators as specified in Section 4.

Specific emergency procedures shall be designed for fires, to protect both in-plant workers and firefighters.

(d) Work Clothing

Workers shall wear work clothing consisting of at least hat, shirt or blouse, pants or skirt, and shoes. Work clothing and street clothing shall be exchanged at the beginning and the end of each workday, so that work clothing will not be worn outside the workplace. The employer shall provide for proper laundry of clothing and shall instruct launderers on procedures to be taken to avoid inhalation of cadmium-containing dusts.

Section 7—Sanitation Practices

(a) Where there is cadmium-containing dust, cleaning should be performed by vacuum pickup or wet mopping. No dry sweeping or blowing shall be permitted.

(b) Emphasis shall be placed upon prompt cleanup of spills, repair of equipment and leaks, proper storage of materials, and collection of cadmium-containing dust.

(c) Cadmium-containing and cadmium-plated metal parts should be kept separate from parts not containing cadmium and marked appropriately so that accidental exposures resulting from welding and cutting will not occur.

(d) Facilities shall be maintained to protect foodstuffs and food consumption areas from contamination by materials containing cadmium. Food storage, handling, and consumption shall be separate from cadmium work areas. Smoking or carrying uncovered tobacco or tobacco products in cadmium work areas shall be prohibited.

(e) Adequate handwashing and shower facilities shall be provided. Workers shall wash their hands before eating or before using tobacco to prevent their absorbing additional amounts of cadmium compounds.

Section 8—Monitoring and Recordkeeping

Workers are not considered to be occupationally exposed to cadmium if environmental concentrations, as determined on the basis of an industrial hygiene survey to be performed within 90 days of the promulgation of a standard, do not exceed the action level, ie, half the recommended TWA environmental limit, or if there is no operation, storage, or handling of cadmium in any form or

contamination of workplace air by cadmium from other sources. These industrial hygiene surveys shall be repeated at least every 3 years and within 30 days after any process or operating change likely to result in increases of airborne concentrations of cadmium. Records of these surveys, including the basis for concluding that airborne concentrations of cadmium are at or below the action level, shall be maintained until the next survey has been completed.

The following requirements apply to occupational exposure to cadmium, ie, to workplaces where the action level is exceeded.

(a) Personal monitoring

A program of breathing zone or personal monitoring shall be instituted to identify and measure the exposure of all employees occupationally exposed to cadmium. This sampling and analysis shall be conducted every 3 months on at least 25% of the workers so that each worker's exposure is measured at least every year; this frequency and fraction of employees sampled may be different if so directed by a professional industrial hygienist. Sufficient numbers of samples shall be collected and analyzed to permit construction of valid estimates of the TWA and ceiling concentration exposures of workers during each workshift; the number of TWA and ceiling concentration determinations for an operation shall be based on such factors as mobility and job functions of workers in that operation. If monitoring of any worker shows exposure in excess of either recommended environmental limit, additional monitoring shall be promptly initiated. If confirmed, control procedures shall be instituted as soon as possible; these may precede and obviate confirmatory monitoring if the employer desires. Affected employees shall be advised that exposures have been excessive and be notified of the control procedures being implemented. Monitoring of these employees' exposures shall be conducted at least as often as every 30 days and shall continue until 2 successive samplings at least a week apart confirm that exposure no longer exceeds recommended limits. Normal monitoring may then be resumed.

(b) Recordkeeping

Environmental monitoring records shall be maintained for at least 20 years. These records shall include methods of sampling and analysis used, types of respiratory protection used, and TWA and ceiling concentrations found. Each employee shall be able to obtain information on his own environmental exposures. Environmental records shall be made available to designated representatives of the Secretary of Labor and of the Secretary of Health, Education, and Welfare.

Pertinent medical records shall be retained for 20 years after the last occupational exposure to cadmium. Records of environmental exposures applicable to an employee should be included in that employee's medical records. These medical records shall be made available to the designated medical representatives of the Secretary of Labor, of the Secretary of Health, Education, and Welfare, of the employer, and of the employee or former employee.

II. INTRODUCTION

This report presents the criteria and the recommended standard based thereon which were prepared to meet the need for preventing impairment of health from occupational exposure to cadmium. 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 consultation with others, formalized a system for the development of criteria upon which standards can be established to protect the health and safety of workers from exposure to hazardous chemical and physical agents. The criteria and recommended standard should enable management and labor to develop better engineering controls and more healthful work practices and should not be used as a final goal.

These criteria for a standard for cadmium are part of a continuing series of criteria developed by NIOSH. The proposed standard applies only to the processing, manufacture, and use of cadmium as applicable under the Occupational Safety and Health Act of 1970.

The standard was not designed for the population-at-large, and any extrapolation beyond general occupational exposures is not warranted. It is intended to (1) protect against injury from cadmium, (2) be measurable by techniques that are valid, reproducible, and available to industry and official agencies, and (3) be attainable with existing technology.

The criteria document reviews sources, uses, distribution, and biologic effects of, and sampling and analytical methods for, cadmium. In selecting from extensive scientific and technical literature on cadmium to prepare this review, emphasis has been given to those studies most relevant to occupational exposure and, where many investigations give similar information, to the more basic or recent articles. For additional information, various reviews are suggested. These include *Cadmium in the Environment* (second edition) by Friberg and coauthors[1] and a supplement *Cadmium in the Environment III*,[2] a shorter review by Riihimaki,[3] the WHO-IARC review of cadmium,[4] EPA's *Scientific and Technical Assessment Report on Cadmium*, [5] a study of *Environmental Impact of Cadmium* by Fleischer et al,[6] *Cadmium, The Dissipated Element*, by Fulkerson and Goeller,[7] and a book *Cadmium* on technology and properties of cadmium and its compounds by Chizhikov from the USSR, available in an English translation.[8]

Cadmium is one of the more thoroughly investigated workplace hazards, and considerable information about occupational health problems associated with cadmium has been developed. Nevertheless, there are important gaps in the knowledge of toxic effects in man at concentrations of cadmium encountered in the workplace. Important gaps include possible effects on male and female gonads, possible birth defects in offspring of workers, and the possibility of cancer, especially among male workers. Conclusions on these and other points arrived at in this document should be verified, refuted, or modified by additional research. In addition, better data are needed on absorption, distribution within the body, accumulation, especially in the kidney, and excretion of cadmium. Research in this area may resolve several questions, including questions about the significance of cadmium in blood and urine to health status and to cadmium absorption.