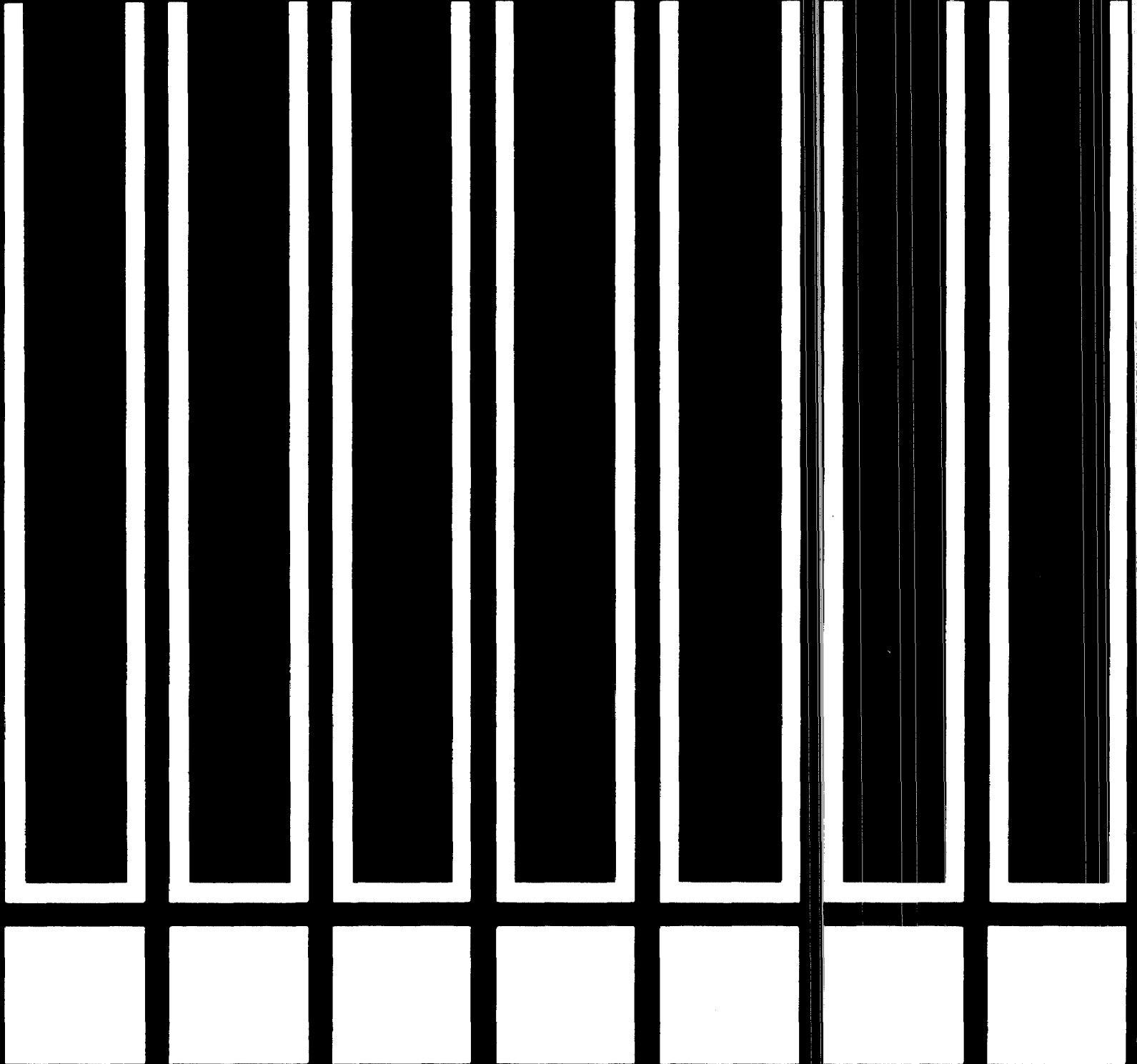


**NIOSH**

**criteria for a recommended standard . . . .**  
**occupational exposure to**  
**INORGANIC NICKEL**



**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  
INORGANIC NICKEL**



**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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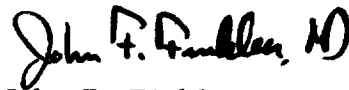
## PREFACE

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 as 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 inorganic nickel by members of the NIOSH staff and the valuable constructive comments by the Review Consultants on Inorganic Nickel, by the ad hoc committee of the American Occupational Medicine Association, and by

Robert B. O'Connor, M.D., NIOSH consultant in occupational medicine. The NIOSH recommendations for standards are not necessarily a consensus of all the consultants and the professional society that reviewed this criteria document on inorganic nickel. A list of Review Consultants appears on page vi.



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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 the recommended standard for inorganic nickel. The division review staff for this document consisted of Keith H. Jacobson, Ph.D. (Chairman), Frank L. Mitchell, D.O., and Richard A. Rhoden, Ph.D., with Harry M. Donaldson (Division of Surveillance, Hazard Evaluations, and Field Studies) and Eula Bingham, Ph.D. Stanford Research Institute (SRI) developed the basic information for consideration by NIOSH staff and consultants under contract No. CDC-99-74-31. Imogene F. Sevin, Ph.D., served as criteria manager.

The views expressed and conclusions reached in this document, together with the recommendations for a standard, are those of NIOSH, after review of the evidence and consideration of the comments of reviewers; these views and conclusions are not necessarily those of the consultants, other federal agencies, and professional societies, or of the contractor.

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· CRITERIA DOCUMENT:  
RECOMMENDATIONS FOR AN OCCUPATIONAL  
EXPOSURE STANDARD FOR INORGANIC NICKEL

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## I. RECOMMENDATIONS FOR AN INORGANIC NICKEL STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that employee exposure to inorganic nickel in the workplace be controlled by adherence to the following sections. The standard is designed to protect the health and provide for the safety of employees for up to a 10-hour work shift, 40-hour workweek, over a working lifetime. Compliance with all sections of the standard should, at the minimum, substantially reduce the risk of nickel-induced cancer and dermatitis and prevent other adverse effects of exposure to nickel in the workplace. The employer should regard the recommended workplace environmental limit as the upper boundary for exposure and make every effort to keep the exposure as low as possible. The criteria and standard will be subject to review and revision as necessary.

Even though the available evidence indicates an association between human exposure to inorganic nickel and the development of cancer, the mixed exposures, both to different nickel compounds and to other elements, frequently occurring in the workplace have prevented complete differentiation of the effects of individual compounds. Should sufficient information become available to indicate that the standard offers greater or lesser protection from some nickel compounds than is needed, it will be considered for revision.

"Nickel" is defined in this standard as elemental nickel and all nickel compounds except organonickel compounds with a covalent carbon-nickel bond, such as nickel carbonyl. "Occupational exposure to nickel" is defined as working with compounds, solutions, or metals containing nickel

that can become airborne or can spill or splash on the skin or in the eyes. Occupational exposure to nickel does not include the handling of solid products, such as stainless-steel tools, provided no particle-generating operations, such as grinding or cutting, occur. The recommended method of sampling and analysis does not differentiate between individual nickel particles; thus, the standard applies to all particulate nickel. Where no occupational exposure to nickel occurs, but nickel is present in the workplace, adherence is required only to Section 8(a).

#### Section 1 - Environmental (Workplace Air)

##### (a) Concentration

Occupational exposure to nickel shall be controlled so that no employee is exposed to nickel at a concentration greater than 15 micrograms, measured as nickel, per cubic meter of air (15  $\mu\text{g Ni/cu m}$ ), determined as a time-weighted average (TWA) concentration for up to a 10-hour work shift, 40-hour workweek.

##### (b) Sampling and Analytical Methods

The TWA concentration limit represents the lowest reliably detectable concentration of nickel measurable by the recommended sampling and analytical methods selected. Procedures for the collection and analysis of environmental samples shall be as provided in Appendices I and II, or by any methods at least equivalent in accuracy, precision, and sensitivity to the methods specified.

## Section 2 - Medical

Medical surveillance shall be provided, as outlined below, to all employees occupationally exposed to nickel.

(a) Preplacement or initial medical examinations for workers shall include:

(1) Comprehensive medical and work histories with special emphasis on skin conditions or allergies, illnesses or sensitizations of the upper and lower respiratory systems, and smoking history.

(2) A complete physical examination giving particular attention to examination of the upper respiratory tract membranes for evidence of irritation, bleeding, ulcerations, or perforations, and examination of the skin for evidence of dermatitis or irritation.

(3) Specific clinical tests, such as a 14" x 17" postero-anterior chest X-ray film and pulmonary function tests including the forced vital capacity (FVC) and forced expiratory volume during the first second (FEV 1). In addition, more specific tests, such as sputum cytology, should be considered by the responsible physician after having evaluated their availability and applicability to the situation. Measurements of concentrations of nickel and protein in urine and administration of a questionnaire to assess symptoms of chronic respiratory disease are also suggested.

(4) A judgment of the employee's ability to use positive or negative pressure respirators.

(b) Initial medical examinations shall be made available to all workers within 6 months after promulgation of a standard based on these recommendations.

(c) Periodic examinations shall be made available at least annually. These examinations shall include:

(1) Interim medical and work histories.

(2) Physical examination as outlined in paragraphs (a)(2) and (a)(3) of this section.

(d) Employees or prospective employees with medical conditions, eg, dermatitis, which may be directly or indirectly aggravated by exposure to nickel shall be further counseled on the increased risk of impairment of their health from working with this substance.

(e) Appropriate medical services shall be made available to any employee with adverse health effects from nickel in the workplace.

(f) In the event of wound contamination by nickel, the wound shall be promptly and thoroughly washed.

(g) Pertinent medical records shall be maintained for all employees exposed to nickel in the workplace. Such records shall be retained for at least 40 years after the last occupational exposure to nickel. These records shall be made available to the designated medical representatives of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, of the employer, and of the employee or former employee.

### Section 3 - Labeling and Posting

A label shall be placed on each shipping and storage container of nickel in liquid, powder, or crystalline form, and all areas where there is occupational exposure to nickel shall be posted.

All labels and warning signs shall be printed both in English and in

the predominant language of non-English-reading workers. Illiterate workers and workers reading languages other than those used on labels and posted signs shall receive information regarding hazardous areas and shall be informed of the instructions printed on labels and signs.

(a) Labeling

Each container of nickel in liquid, powder, or crystalline form shall carry in a readily visible location a label stating:

NAME OF COMPOUND

(Trademark, Common Name, or Chemical Name)

DANGER! CONTAINS NICKEL  
INHALATION IS HAZARDOUS AND MAY CAUSE NASAL OR LUNG CANCER  
SKIN CONTACT MAY CAUSE IRRITATION OR RASH

Keep container closed.  
Avoid breathing dust, fume, or mist.  
Use only with adequate ventilation.  
Do not get in eyes, in open wounds, or on skin or clothing.

First Aid: In case of skin or eye contact or contact with an open wound, flush promptly with running water.

(b) Posting

Warning placards shall be affixed in readily visible locations in or near areas where there is occupational exposure to nickel. The information shall be arranged as in the following example.

NICKEL

DANGER!

INHALATION CAN BE HARMFUL AND MAY CAUSE NASAL OR LUNG CANCER  
SKIN CONTACT MAY CAUSE IRRITATION OR RASH

AUTHORIZED PERSONNEL ONLY

Do not get in eyes, in open wounds, or on skin or clothing.

First Aid: In case of skin or eye contact or contact with an open wound, flush promptly with running water.

If respiratory protection is required in accordance with Section 4, the following statement in large letters shall be added to the required sign:

RESPIRATORY PROTECTION REQUIRED IN THIS AREA

Section 4 - Personal Protective Clothing and Equipment

(a) Protective Clothing

(1) The employer shall provide safety goggles or face shields (8-inch minimum) with goggles and shall ensure that employees wear the protective equipment during any operation in which nickel may enter the eyes.

(2) The employer shall provide appropriate protective clothing, such as gloves, aprons, suits, hats, or face shields, for employees, such as platers, who are likely to have appreciable skin contact with nickel, and for those who are especially sensitive to nickel.

(b) Respiratory Protection

(1) Engineering controls shall be used when needed to keep concentrations of airborne nickel at or below the recommended TWA concentration limit. Respiratory protective equipment may be used in the following circumstances:

(A) During the time necessary to install or test the required engineering controls.

(B) For operations such as nonroutine maintenance and repair activities in which brief exposure at concentrations in excess of the TWA concentration limit may occur.

(C) During emergencies when concentrations of airborne nickel might exceed the TWA concentration limit.

(2) When a respirator is permitted by paragraph (b)(1) of this section, it shall be selected and used in accordance with the following requirements:

(A) The employer shall establish and enforce a respiratory protective program. The requirements for such a program are listed in 29 CFR 1910.134.

(B) The employer shall provide respirators in accordance with Table I-1 and shall ensure that employees use the respirators in a proper manner when the concentration of airborne nickel exceeds the recommended TWA concentration limit. The respirators shall be those approved by NIOSH or the Mining Enforcement and Safety Administration. The standard for approval is specified in 30 CFR 11. The employer shall ensure that respirators are properly cleaned, maintained, and stored when not in use.



TABLE I-1  
RESPIRATOR SELECTION GUIDE

Concentration of Nickel	Respirator Type Approved under Provisions of 30 CFR 11
Greater than 15 $\mu\text{g}/\text{cu m}$ or <u>Emergency</u> (entry into area of unknown concentration for emergency purposes)	(1) Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode (2) Combination Type C supplied-air respirator with full facepiece operated in pressure-demand mode and auxiliary self-contained air supply

(C) Escape equipment shall be located at clearly identified stations within the work area and shall be adequate to permit all employees to escape safely from the area. Protective equipment suitable for emergency entry shall be located at clearly identified stations outside the work area.

Section 5 - Informing Employees of Hazards from Nickel

(a) The employer shall ensure that each employee assigned to work in an area where there is occupational exposure to nickel is informed of the hazards and relevant symptoms of exposure to nickel, and of proper conditions and precautions for the handling and use of nickel. Workers shall be advised that handling nickel may cause dermatitis and that exposure to airborne nickel may increase the risk of developing cancer of the respiratory organs. Information shall be given to employees at the beginning of employment and at least twice a year thereafter.

(b) The employer shall institute a continuing education program, conducted by instructors qualified by experience or training, to ensure that all employees have current knowledge of job hazards, proper maintenance and cleanup methods, and proper respirator use. The instructional program shall include a description of the environmental and medical surveillance procedures and of the advantages to the employee of participating in these examinations. Instruction shall include the information specified in Appendix IV, which shall be kept on file and readily accessible to employees at all places of employment where there is occupational exposure to nickel. Workers engaged in maintenance and repair shall be included in these training programs.

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

#### Section 6 - Work Practices

(a) Control of Airborne Nickel

Engineering controls, such as process enclosure or local exhaust ventilation, shall be used whenever feasible and necessary to keep concentrations of airborne nickel at or below the recommended TWA concentration limit. If used, ventilation systems shall be so designed and operated as to prevent accumulation or recirculation of airborne nickel in the workplace environment and to effectively remove nickel from the breathing zone of employees. Exhaust ventilation systems discharging to outside air must conform to applicable local, state, and federal regulations and must not constitute hazards to employees or to the general

population. Before maintenance work on control equipment begins, sources of airborne nickel shall be eliminated to the extent feasible.

Enclosures, exhaust hoods, and ductwork shall be kept in good repair so that design airflows are maintained. Airflow at each hood shall be measured 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 shall be kept showing design airflow and results of semiannual inspections.

(b) Regulated Areas

Regulated areas shall be established and maintained where there is occupational exposure to nickel, and access to these areas shall be limited to authorized persons.

(c) Cleanup of Spills

Dusts or solutions containing nickel shall be removed from work areas by vacuum cleaning or by other methods, including wet methods, which do not increase the concentration of airborne nickel. No dry sweeping, blowing by compressed air, or any other method of dust removal that increases the concentration of airborne nickel shall be allowed.

(d) Emergency Procedures

Procedures for emergencies, including fires and the inadvertent formation of nickel carbonyl, shall be established to meet foreseeable events. Necessary emergency equipment shall be kept in readily accessible locations. Where appropriate, respirators shall be available for use during evacuation.

(e) Disposal of Waste

Waste material shall be disposed of in a manner that is not hazardous to employees or to the general population. Nickel wastes shall be appropriately marked and any aerosol-generating operations shall be enclosed. In selecting the method of waste disposal, applicable local, state, and federal regulations should be consulted.

(f) Storage

Containers of nickel in liquid, powder, or crystalline form shall be kept tightly closed when not in use. Containers shall be stored in a safe manner to minimize the possibility of accidental breakage or spills. Corrosion of nickel shall also be minimized during storage.

(g) General Work Practices

(1) Good housekeeping practices shall be observed to prevent contamination of areas and equipment with nickel dusts, liquids, or mists and to prevent buildup of such contamination.

(2) Good personal hygiene practices should be encouraged. Employees who have skin or eye contact with nickel should promptly and thoroughly wash the affected part. Workers occupationally exposed to nickel shall be required to shower at the end of the workshift.

(h) Work Clothing

(1) Coveralls or similar full-body protective clothing and head, leg, and shoe coverings, fire retardant where necessary, shall be worn by each employee occupationally exposed to nickel.

(2) Such clothing shall be changed daily at the end of the work shift or if accidentally contaminated with nickel.

(3) The employer shall provide for the laundering of this clothing and shall ensure that soiled work clothing is not taken home by the employee. Precautions shall be taken to protect personnel who handle and launder soiled clothing. These workers shall be advised of the hazards of and means of preventing exposure to nickel.

Section 7 - Sanitation

(a) Conveniently located washing facilities shall be provided for all employees occupationally exposed to nickel. Locker-room facilities, including showers, located in nonexposure areas, shall be provided for employees required to change clothes before and after each work shift. The facilities shall provide for storage of street clothing and clean work clothing separately from soiled work clothing. Covered containers shall be provided for work clothing removed at the end of the work shift or after a contamination incident. The clothing shall be held in these containers until it is removed for decontamination or disposal.

(b) Food preparation, dispensing (including vending machines), and eating shall be prohibited in areas where there is occupational exposure to nickel.

(c) Smoking or carrying uncovered smoking or chewing materials, such as chewing tobacco and gum, shall be prohibited in work areas where there is occupational exposure to nickel.

Section 8 - Monitoring and Recordkeeping Requirements

(a) Monitoring

(1) Within 6 months of the promulgation of a standard based on these recommendations, each employer who has a place of employment in which nickel is refined, handled, stored, or otherwise used shall determine by an industrial hygiene survey if occupational exposure to nickel may occur. Surveys shall be repeated at least once every year and within 30 days of any process change likely to result in occupational exposure to nickel. Records of these surveys, including the basis for any conclusion that there is no occupational exposure to nickel, shall be retained until the next survey has been completed.

(2) If occupational exposure to nickel is possible, a program of personal monitoring shall be instituted to measure or permit calculation of the exposure of all employees.

(A) In all personal monitoring, samples representative of the breathing zones of the employees shall be collected.

(B) For each TWA determination, a sufficient number of samples shall be taken to characterize the employees' exposures during each work shift. Variations in work and production schedules and in employees' locations and job functions shall be considered in choosing sampling times, locations, and frequencies.

(C) Each operation in each work area shall be sampled at least once every 3 months.

(3) If an employee is found to be exposed to nickel in excess of the recommended TWA concentration limit, the exposure of that employee shall be measured at least once a week, control measures shall be

initiated, and the employee shall be notified of the extent of the exposure and of the control measures being implemented. Such monitoring shall continue until two consecutive determinations, 1 week apart, indicate that the employee's exposure no longer exceeds the recommended TWA concentration limit. Routine monitoring may then be resumed.

(b) Recordkeeping

Environmental monitoring records shall be maintained for at least 40 years after the employee's last occupational exposure to nickel. These records shall include the dates and times of measurements, job function and location of employees within the worksite, methods of sampling and analysis used, types of respiratory protection in use at the time of sampling, TWA concentrations found, and identification of exposed employees. Each employee shall be able to obtain information on that employee's own environmental exposures. Daily rosters of authorized persons who enter regulated areas shall be retained for 40 years. Environmental monitoring records and entry rosters shall be made available to designated representatives of the Secretary of Labor and of the Secretary of Health, Education, and Welfare.

Pertinent medical records for each employee shall be retained for 40 years after the employee's last occupational exposure to nickel. 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 inorganic nickel. 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 to provide for the safety of employees exposed 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 inorganic nickel are part of a continuing series of criteria developed by NIOSH. The proposed standard applies to the processing, manufacture, and use of inorganic nickel 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 occupational exposures is not warranted. The standard



is intended to (1) protect against injury from inorganic nickel, (2) be measurable by techniques that are valid, reproducible, and available to industry and official agencies, and (3) be attainable with existing technology. However, it will only substantially reduce the risk of developing nickel-related cancers and minimize the risk of developing dermatitis.

Ingestion and inhalation of, and dermal exposure to, nickel are common, since nickel is present in air, soil, water, food, and household objects. Although nickel is commonly found in the air, it is present in higher concentrations where there is environmental pollution as a result of the burning of fossil fuels or the processing of nickel.

The recommended standard for inorganic nickel is based on the conclusion that these substances are carcinogenic. An excess number of deaths from lung cancer and nasal cancer has been observed in nickel refinery workers. After review of the relevant data, it was concluded that a substantial portion of those excess deaths was caused by exposure to airborne nickel compounds. It might be reasoned from the limited animal data that only nickel subsulfide is a carcinogen; or the interpretation might be made, based on some epidemiologic studies, that only one stage of nickel refining presents a risk of cancer. In addition, it might be concluded from limited data on human exposures and environmental concentrations that the safe threshold level of exposure to nickel compounds is greater than the recommended environmental limit. Should sufficient evidence be developed to demonstrate that any of these is a correct interpretation or that some nickel compounds are not carcinogenic,

the recommended standard for inorganic nickel will be considered for revision.

The available evidence indicates that workers can be adversely affected by skin contact with nickel, particularly when it is in solution. Because of the ubiquity of nickel in the nonoccupational environment, some individuals may develop a sensitivity to nickel regardless of precautions taken in the workplace. The standard cannot protect these individuals from developing recurrent dermatitis when occupationally exposed to inorganic nickel. However, it will greatly reduce the risk of unsensitized workers becoming sensitive to nickel in the course of their employment.

Even though there is considerable information about occupational health problems associated with inorganic nickel, several major areas require further research. Epidemiologic studies are needed to determine the risk of developing nickel-related cancers in occupations which have not been adequately studied, eg, welding, plating, and refining nickel oxide ore; inhalation experiments in suitable animal species are needed to supplement these studies. Both animal and human studies are needed to ascertain whether the limited information on reproductive effects has any relevance to human exposure. Animal studies are needed to characterize the acute and chronic toxicities of the many nickel compounds for which insufficient information is available.

The health effects of occupational exposure to nickel carbonyl are not discussed in this document, nor have the effects of simultaneous exposure to nickel and cadmium been reviewed herein. The effects of nickel carbonyl are discussed in "Special Occupational Hazards Review and Control Recommendations for Nickel Carbonyl" and the effects of cadmium are

discussed in the "Criteria for a Recommended Standard--Occupational Exposure to Cadmium."

Two other reviews of nickel provide additional information on its toxicity. The International Agency for Research on Cancer (IARC) prepared monographs on nickel and nickel compounds in 1973 [1] and 1976 [2], in which evidence for the carcinogenicity of all nickel compounds was considered. The Committee on Medical and Biologic Effects of Environmental Pollutants of the National Academy of Sciences published in 1975 a comprehensive review (NAS-NRC report) [3] of nickel which also included nickel carbonyl.