

NIOSH/OSHA STANDARDS COMPLETION PROGRAM

DRAFT TECHNICAL STANDARD AND
SUPPORTING DOCUMENTATION FOR

*** NICKEL, METAL AND SOLUBLE COMPOUNDS AS NI ***

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NIOSH/OSHA Draft Technical Standard
and Supporting Documentation for NICKEL, METAL AND SOLUBLE COMPOUNDS AS NI

The basic text of this document contains the draft technical standard approved by the Joint Review Committee of the NIOSH/OSHA Standards Completion Program and the supporting documentation for the substance NICKEL, METAL AND SOLUBLE COMPOUNDS AS NI.

The SCP draft technical standards are recommendations to the Department of Labor for its consideration in rulemaking and have no legal status until final rules have been promulgated by that agency. This draft standard is provided for your information only.

The References and Sources, Respirator Table Documentation and Use/Exposure and Control Documentation are the working documents used by the various SCP working groups during the development of the draft technical standard and serve as the technical foundation for the standard. The classification for each substance and the regulatory statements were derived following a decision logic established for the various sections of the standard.

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(a) Definitions. (1) "Permissible exposure" means exposure of employees to airborne concentrations of nickel metal and soluble compounds (as Nickel) not in excess of 1 milligram per cubic meter (mg/M3), averaged over an eight-hour work shift (time weighted average), as stated in § 1910.1000, Table Z-1.

(2) "Action level" means one half of the permissible exposure for nickel metal and soluble compounds.

(3) Nothing in this standard shall apply to Nickel Carbonyl.

(b) Exposure determination and measurement. (1) Each employer who has a place of employment in which nickel metal and soluble compounds is released into the workplace air shall determine if any employee may be exposed to airborne concentrations of nickel metal and soluble compounds at or above the action level. The determination shall be made each time there is a change in production, process, or control measures which could result in an increase in airborne concentrations of nickel metal and soluble compounds.

(2) A written record of the determination shall be made and shall contain at least the following information:

(i) Any information, observations, or calculations which may indicate employee exposure to nickel metal and soluble compounds;

(ii) Any measurements of nickel metal and soluble compounds taken;

(iii) Any employee complaints of symptoms which may be attributable to exposure to nickel metal and soluble compounds; and

(iv) Date of determination, work being performed at the time, location within work site, name, and social security number of each employee considered.

(3) If the employer determines that any employee may be exposed to nickel metal and soluble compounds at or above the action level, the exposure of the employee in each work operation who is believed to have the greatest exposure shall be measured. The exposure measurement shall be representative of the maximum eight-hour time weighted average exposure of the employee.

(4) If the exposure measurement taken pursuant to paragraph (b) (3) of this section reveals employee exposure to nickel metal and soluble compounds at or above the action level, the employer shall:

(i) Identify all employees who may be exposed at or above the action level; and

(ii) Measure the exposure of the employees so identified.

(5) If an employee exposure measurement reveals that an employee is exposed to nickel metal and soluble compounds at or above the action level, but not above the permissible exposure, the exposure of that employee shall be measured at least every two months.

(6) If an employee exposure measurement reveals that an employee is exposed to nickel metal and soluble compounds above the permissible exposure, the employer shall:

(i) Measure the exposure monthly of the employee so exposed; and

(ii) Institute control measures as required by paragraph (d) of this section; and

(iii) Individually notify, in writing, within five days, every employee who is found to be exposed to nickel metal and soluble compounds above the permissible exposure. The employee shall also be notified of the corrective action being taken to reduce the exposure to at or below the permissible exposure.

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(7) If two consecutive employee exposure measurements taken at least one week apart reveal that the employee is exposed to nickel metal and soluble compounds below the action level, the employer may terminate measurement for the employee.

(8) For purposes of this paragraph, employee exposure is that which would occur if the employee were not using a respirator.

(c) Methods of measurement. (1) An employee's exposure shall be obtained by any combination of long term or short term samples which represents the employee's actual exposure, averaged over an eight-hour work shift (See Appendix B (iv) of this section).

(2) The method of measurement shall have an accuracy, to a confidence level of 95 percent, of not less than that given in Table 1.

Table 1

Concentration

Required Accuracy

Above permissible exposure

$\pm 25\%$

At or below permissible exposure

and above the action level

$\pm 35\%$

At or below the action level

$\pm 50\%$

(d) Compliance. (1) No employee shall be exposed to nickel metal and soluble compounds above the permissible exposure as defined in paragraph (a)(1) of this section.

(2) Employee exposures to airborne concentrations of nickel metal and soluble compounds shall be controlled to at or below the permissible exposure by engineering and work practice controls:

(i) Engineering and work practice controls shall be instituted to reduce exposures to at or below the permissible exposure, except to the extent that such controls are not technically feasible.

(ii) Wherever engineering and work practice controls are not sufficient to reduce exposures to at or below the permissible exposure, they shall nonetheless be used to reduce exposure to the lowest level feasible and shall be supplemented by respirators in accordance with paragraph (d)(4) of this section.

(3) Engineering controls. (i) When mechanical ventilation is used to control exposure, measurements which demonstrate system effectiveness, for example, air velocity, static pressure, or air volume, shall be made at least every three months. Measurements of system effectiveness shall also be made within five days of any change in production, process, or control which might result in an increase in airborne concentrations of nickel metal and soluble compounds.

(ii) Open-surface tank operations shall be performed in accordance with § 1910.94(d).

(4) Compliance with the permissible exposure shall not be achieved by the use of respirators except:

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- (i) During the time period necessary to install or implement engineering or work practice controls; or
 - (ii) In work situations in which engineering and work practice controls are technically not feasible; or
 - (iii) To supplement engineering and work practice controls when such controls fail to reduce airborne concentrations of nickel metal and soluble compounds to at or below the permissible exposure; or
 - (iv) For operations which require entry into tanks or closed vessels; or
 - (v) In emergencies.
- (5) Where respirators are needed and permitted under this paragraph to reduce employee exposure, the employer shall select and provide the appropriate respirator from Table 2 and shall ensure that the employee uses the respirator provided.

TABLE 2 RESPIRATORY PROTECTION FOR NICKEL METAL AND SOLUBLE COMPOUNDS

CONDITION	PERMISSIBLE RESPIRATORY PROTECTION
Dust or Mist Concentration	
5 mg/M3 or less	Any dust and mist respirator.
10 mg/M3 or less	Any dust and mist respirator, except single-use or quarter-mask respirator.
Dust, Mist or Fume Concentration	
10 mg/M3 or less	Any fume respirator or high efficiency particulate filter respirator.
	Any supplied-air respirator.
	Any self-contained breathing apparatus.
50 mg/M3 or less	A high efficiency particulate filter respirator with a full facepiece.
	Any supplied-air respirator with a full facepiece, helmet or hood.
	Any self-contained breathing apparatus with a full facepiece.
1000 mg/M3 or less	A powered air-purifying respirator with a high efficiency particulate filter.
	A Type C supplied-air respirator operated in pressure demand or other positive pressure or continuous-flow mode.

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2000 mg/M3 or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet or hood operated in continuous-flow mode.
Greater than 2000 mg/M3 or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.

(6) Respirators shall be approved by the Mining Enforcement and Safety Administration (formerly Bureau of Mines) or by the National Institute for Occupational Safety and Health under the provisions of 30 CFR Part 11.

(7) The employer shall institute a respiratory protection program in accordance with § 1910.134(b), (d), (e), and (f).

(e) Fire and safety. (1) The employer shall familiarize himself with the information contained in the Substance Technical Guidelines (Appendix B of this section) for nickel.

(2) Nickel sponge catalyst shall be stored so as not to come in contact with air.

(3) For the purpose of compliance with § 1910.157, nickel is classified as a Class D fire hazard except that § 1910.157(b)(2)(v) shall not apply.

(4) Sources of ignition such as smoking or open flames are prohibited where nickel presents a fire or explosion hazard.

(5) Nickel shall be stored so as not to come in contact with strong acids and sulfur.

(f) Personal protective equipment. (1) Employers shall provide and ensure that employees use impervious clothing, gloves, face shields (eight-inch minimum) and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with powdered metallic nickel or solids or liquids containing soluble nickel compounds. Face shields shall comply with § 1910.133(a)(2), (a)(4), (a)(5), and (a)(6).

(2) Employers shall ensure that employees whose clothing may have become contaminated with powdered metallic nickel or solid soluble nickel compounds change into uncontaminated clothing before leaving the work premises.

(3) Employers shall ensure that clothing contaminated with metallic nickel or soluble nickel compounds is placed in closed containers for storage until it can be discarded or until the employer provides for the removal of the metallic nickel or soluble nickel compounds from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the metallic nickel or soluble nickel compounds, the employer shall

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inform the person performing the operation of the hazardous properties of these substances.

(4) Employers shall ensure that non-impervious clothing which becomes contaminated with metallic nickel or soluble nickel compounds be removed promptly and not reworn until the metallic nickel or soluble nickel compounds are removed from the clothing.

(g) Spills and disposal. In the event that powdered metallic nickel or soluble nickel compounds are spilled the employer shall immediately provide available ventilation and then clean up the spill.

(h) Sanitation. (1) Employers shall ensure that employees whose skin becomes contaminated with metallic nickel or soluble nickel compounds promptly wash or shower with soap or mild detergent and water to remove any metallic nickel or soluble nickel compounds from the skin.

(2) Employers shall ensure that employees do not eat or smoke in areas where solids or liquids containing soluble nickel compounds are handled, processed or stored.

(3) Employers shall ensure that employees who handle powdered metallic nickel or solids or liquids containing soluble nickel compounds wash their hands thoroughly with soap or mild detergent and water before eating, smoking or using toilet facilities.

(i) Training and information. (1) Each employer who has a workplace in which nickel metal and soluble compounds is present shall keep a copy of this regulation with Appendixes A, B and C at the workplace. This material shall be made readily available to affected employees.

(2) Each employer who has employees exposed to nickel metal and soluble compounds above the action level or employees who may have skin or eye contact with powdered metallic nickel or solids or liquids containing soluble nickel compounds, or employees who work where nickel presents a potential fire or explosion hazard, shall annually:

(i) Inform affected employees of the information contained in the Substance Safety Data Sheet for nickel metal and soluble compounds (Appendix A of this section);

(ii) Advise affected employees as to the signs and symptoms of exposure to nickel metal and soluble compounds.

(iii) Instruct affected employees to advise the employer of the development of signs and symptoms of exposure to nickel metal and soluble compounds which are listed in Appendix A of the section; and

(iv) Provide training to ensure that employees understand the precautions of safe use, emergency procedures, and the correct use of protective equipment relative to nickel metal and soluble compounds.

(j) Medical surveillance. (1) The employer shall provide medical procedures as required by this paragraph. All medical procedures shall be performed by or under the supervision of a physician at no cost to the employee.

(2) The employer shall make available to each employee who is to be exposed to nickel metal and soluble nickel compounds, or liquids containing soluble nickel compounds or airborne concentrations of nickel metal and soluble nickel compounds at or above the action level a medical examination which shall include the following:

(i) A medical history and physical examination with emphasis on the nasal cavities, lungs and skin.

(ii) 14" x 17" chest roentgenogram.

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(3) The employer shall obtain from the physician, as a record of the examination, the following information:

(i) A written opinion which conforms with paragraph (j)(7) of this section.

(ii) 14" x 17" chest roentgenogram or medically acceptable copy.

(4) The employer shall make available to each employee, exposed to nickel metal and soluble nickel compounds in excess of the action level at 12 months from the date of the employee's first exposure, and at every 12 months of exposure in excess of the action level thereafter, a medical examination which must include the following:

(i) A medical history and physical examination with emphasis on the nasal cavities, lungs and skin.

(ii) 14" x 17" chest roentgenogram.

(5) The employer shall obtain from the physician, as a record of the periodic examination, the following information:

(i) A written opinion which conforms with paragraph (j)(7) of this section.

(ii) 14" x 17" chest roentgenogram or medically acceptable copy.

(6) The employer shall provide to the examining physician the following information:

(i) A copy of this regulation with its Appendixes A, B, and C for nickel metal and soluble nickel compounds;

(ii) A description of the employee's duties as they relate to his exposure to nickel metal and soluble nickel compounds;

(iii) A description of any personal protective equipment and respirators required to be used;

(iv) The results of any measurements, which may indicate the affected employee's exposure;

(v) The affected employee's anticipated exposure; and

(vi) Upon request of the physician, any available information from previous medical examination of the affected employee.

(7)(i) The physician's written opinion shall be a signed statement by the examining physician specifically stating: (A) Whether the employee has any detected medical condition which would place the employee at increased risk of material impairment of the employee's health from exposure to nickel metal and soluble nickel compounds or would directly or indirectly aggravate any detected medical condition;

(B) Any recommended limitations upon the employee's exposure to nickel metal and soluble nickel compounds, including limitations upon the use of personal protective equipment and respirators;

(C) That the employee has been informed by the physician of any detected medical conditions which require further medical examination or treatment.

(ii) The physician's written opinion shall not reveal specific medical findings or diagnoses unrelated to exposure to nickel metal and soluble nickel compounds.

(iii) The employer shall provide the employee with a copy of the physician's written opinion.

(8) No employee shall be exposed to nickel metal and soluble nickel compounds or liquids containing soluble nickel compounds of airborne concentrations of nickel metal and soluble nickel compounds in such a way as would put the employee at increased risk of material impairment of his

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health from such exposure. This determination may be based on the physician's written opinion.

(9) The employer shall provide emergency and follow-up medical examinations and treatment for any employee injured through exposure to nickel metal and soluble nickel compounds.

(10) If the examining physician chooses to use alternative medical examinations to those specified in paragraphs (j)(2) and (4) of this section, the employer may accept such alternative medical surveillance examinations as meeting the requirements of this part provided that the employer:

(i) Obtains a statement from the examining physician setting forth the alternative medical examinations and the rationale for substitution and evidence that they will be equally effective.

(ii) Informs each exposed employee of the fact that alternative medical examinations to those required in paragraphs (j)(2) or (4) of this section are to be made available.

(11) If an employee refuses any required medical examination, the employer shall inform the employee of the possible health consequences of such refusal and obtain a signed statement from the employee indicating that the employee understands the risks involved by refusing to be examined.

(12) No medical procedure which would be performed pursuant to this section need be performed if records of a previous such procedure performed within the past six months are acceptable to the examining physician.

(k) Recordkeeping. (1) Exposure determination. (i) The employer shall keep an accurate record of all determinations required to be made pursuant to paragraph (b)(1) of this section.

(ii) This record shall include the written determination required in paragraph (b)(2) of this section.

(iii) This record shall be maintained until replaced by a more recent record.

(2) Exposure measurements. (i) The employer shall keep an accurate record of all measurements taken to determine employee exposure to nickel metal and soluble compounds.

(ii) This record shall include:

(A) The date of measurement;

(B) Operations involving exposure to nickel metal and soluble compounds which are being monitored;

(C) Sampling and analytical methods used and evidence of their accuracy, including the method, results and date of calibration of sampling equipment;

(D) Number, duration, and results of samples taken; and

(E) Name, social security number and exposure of the employee monitored.

(iii) This record shall be maintained until replaced by a more recent record but in no event for less than one year.

(3) Mechanical ventilation. (i) When mechanical ventilation is used as an engineering control, the employer shall maintain an accurate record of the measurements demonstrating the effectiveness of such ventilation required by paragraph (d)(3) of this section.

(ii) This record shall include:

(A) Date of measurement;

(B) Type of measurement taken;

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(C) Result of measurement.

(iii) These records shall be maintained for at least one year.

(4) Employee training and information. (i) The employer shall keep an accurate record of all employee training and information required by paragraph (i) of this section.

(ii) This record shall include:

(A) Date of training;

(B) Name and social security number of employee trained;

(C) Content or scope of training provided.

(iii) This record shall be maintained until replaced by a more recent record.

(5) Medical surveillance. (i) The employer shall keep an accurate record of employee medical surveillance required by paragraph (j) of this section.

(ii) This record shall include:

(A) Results of tests required by paragraph (j)(2) and (j)(3) of this section and results of any tests conducted pursuant to paragraphs (j)(4) of this section;

(B) Any employee medical complaints relative to exposure to nickel metal and soluble compounds;

(C) A copy of information provided to the physician pursuant to paragraph (j)(6)(ii), (iii), (iv), (v), and (vi) of this section.

(D) Physician's written opinion; and

(E) A signed statement of any refusal to be examined.

(iii) This record shall be maintained for the duration and for thirty years after termination of the employment of the affected employee.

(6) Access to records. (i) All records required to be maintained by this section shall be made available upon request to authorized representatives of the Assistant Secretary of Labor for Occupational Safety and Health and the Director of the National Institute for Occupational Safety and Health.

(ii) Employee exposure determination and exposure measurement records required to be maintained by this section shall be made available to employees and former employees and their designated representatives.

(iii) Employee medical records required to be maintained by this section shall be made available upon written request to a physician designated by the employee or former employee.

(1) Employee observation of measurement. (1) The employer shall give affected employees or their representatives an opportunity to observe any measurement of employee exposure to nickel metal and soluble compounds which is conducted pursuant to this section.

(2) When observation of measurement of employee exposure to nickel metal and soluble compounds requires entry into an area where the use of personal protective devices, including respirators, is required, the observer shall be provided with and required to use such equipment and comply with all other applicable safety procedures.

(3) Without interfering with the measurement, observers shall be entitled to:

(i) Receive an explanation of the measurement procedure.

(ii) Visually observe all steps related to the measurement of the airborne concentration of nickel metal and soluble compounds that are being performed at the place of exposure; and

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(iii) Record the results obtained.

NOTE: The information contained in the following appendixes is advisory in nature and is not intended, by itself, to create any additional obligations not otherwise imposed or detract from any existing obligation.

APPENDIX A

SUBSTANCE SAFETY DATA SHEET

FOR NICKEL METAL AND SOLUBLE COMPOUNDS (AS Ni)

I. SUBSTANCE IDENTIFICATION

- A. Substance: Nickel metal and soluble compounds
- B. Permissible Exposure: 1 milligram of nickel metal and soluble compound per cubic meter of air (mg/M3) averaged over an eight-hour work shift.
- C. Appearance and Odor: Nickel, metallic: Silvery gray, metallic (or darker), odorless powder; nickel nitrate hexahydrate: Green, odorless solid; nickel sulfate hexahydrate: Green, odorless solid

II. HEALTH HAZARD DATA

- A. Ways in which the chemical affects your body: Metallic nickel or soluble nickel compounds can affect your body if you inhale them or if they come in contact with your eyes or skin. They may also affect your body if you swallow them.
 - 1. Exposure: Nickel fumes are respiratory irritants and may cause pneumonitis. Skin contact may cause an allergic skin rash. Nickel and its compounds have been reported to cause cancer of the lungs and sinuses. Nickel itself is not very toxic if swallowed but its soluble salts are quite toxic, and if swallowed may cause giddiness and nausea. Exposure to nickel carbonyl (by inhalation or skin absorption) may cause both initial and delayed symptoms. Initial symptoms include headache, dizziness, shortness of breath and vomiting. These symptoms generally disappear when the worker is exposed to fresh air. The delayed symptoms may develop 12 to 36 hours after exposure. The shortness of breath returns, a blue color of the skin may appear and a fever may develop. The exposed person may become delirious. In some cases the symptoms may run together. Death may occur.
 - 2. Reporting Signs and Symptoms: You should inform your employer if you develop any signs or symptoms and

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suspect that they are caused by exposure to metallic nickel or soluble nickel compounds.

III. EMERGENCY FIRST AID PROCEDURES

- A. Skin Exposure: If solids or liquids containing soluble nickel compounds get on your skin, immediately flush the contaminated skin with water. If solids or liquids containing soluble nickel compounds penetrate through your clothing, remove the clothing immediately and flush the skin with water. If irritation persists after washing, get medical attention. Metallic nickel should be removed from the skin by washing with soap or mild detergent and water.
- B. Breathing: If you or any other person breathes in large amounts of metallic nickel or soluble nickel compounds move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible. If any nickel carbonyl has been inhaled, get medical attention promptly.
- C. Swallowing: When metallic nickel or solids or liquids containing soluble nickel compounds have been swallowed, give the person large quantities of water immediately. give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.
- F. Rescue: Move affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty yourself. Understand your emergency rescue procedures and know the locations of the equipment before the need arises.

IV. RESPIRATORS AND PROTECTIVE CLOTHING

- A. Respirators: Respirators are not the best way to control exposure to nickel metal and soluble compounds. You can only be required to wear them for routine use if your employer is in the process of installing controls or control measures prove inadequate. You may be required to wear respirators for non-routine activities or in emergencies. If respirators are worn, they must have a Mining Enforcement and Safety Administration (MESA) or National Institute for Occupational Safety and Health (NIOSH) approval label. (Older respirators may have a Bureau of Mines approval label.) For effective protection, respirators must fit your face and head snugly. Respirators should not be loosened or removed in work situations where their use is required. If you experience difficulty breathing while wearing a respirator, tell your employer.
- B. Protective Clothing: You must wear impervious clothing, gloves, face shield or other appropriate protective clothing to prevent repeated or prolonged skin contact with powdered metallic nickel or solids or liquids containing soluble

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nickel compounds. Replace or repair impervious clothing that has developed leaks.

C. Eye Protection: Not applicable.

V. PRECAUTIONS FOR SAFE USE, HANDLING AND STORAGE

A. Nickel is a combustible solid and under certain conditions, its dust can form explosive mixtures with air.

B. Nickel must be stored in tightly closed containers in a cool, well ventilated area away from heat, strong acids and sulfur. Nickel sponge catalyst must be stored so as not to come in contact with air.

C. Sources of ignition such as smoking and open flames are prohibited wherever nickel is handled, used or stored in a manner that could create a potential fire or explosion hazard.

D. If your work clothing may have become contaminated with powdered metallic nickel or solid soluble compounds of nickel, you must change into uncontaminated clothing before leaving the work premises.

E. You must promptly remove any non-impervious clothing that becomes contaminated with metallic nickel or soluble nickel compounds and this clothing must not be reworn until the nickel is removed from the clothing.

F. If your skin becomes contaminated with metallic nickel or soluble nickel compounds, you must promptly wash or shower with soap or mild detergent and water to remove the nickel from your skin.

G. You must not eat or smoke in areas where solids or liquids containing soluble nickel compounds are handled, processed or stored.

H. If you handle powdered metallic nickel or solids or liquids containing soluble nickel compounds, you must wash your hands thoroughly with soap or mild detergent and water before eating, smoking or using toilet facilities.

I. Fire extinguishers, where provided, must be readily available and you should know where they are and how to operate them.

J. Ask your supervisor where nickel metal and soluble nickel compounds are used in your work area and for any additional safety and health rules.

VI. ACCESS TO INFORMATION

A. Each year your employer is required to inform you of the information contained in this Substance Safety Data Sheet for nickel metal and soluble compounds. In addition, your employer must instruct you in the safe use of nickel metal and soluble compounds, emergency procedures, and the correct use of protective equipment.

B. Your employer is required to determine whether you are being exposed to nickel metal and soluble compounds. You or your representative have the right to observe employee exposure measurements and to record the results obtained. If your employer determines that you are being overexposed, he is required to inform you of the exposure and of the actions which are being taken to reduce your exposure.

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- C. Your employer is required to keep records of exposure determinations, exposure measurements, and medical surveillance. Your employer is required to make records of exposure determinations and your exposure measurements available to you or your representative upon your request. Your employer is required to release your medical records to your physician upon your written request.

APPENDIX B

SUBSTANCE TECHNICAL GUIDELINES
FOR NICKEL METAL AND SOLUBLE COMPOUNDS

(This standard for nickel metal and soluble compounds should not be interpreted to apply only to the substances listed below for which substance specific information has been provided.)

I. PHYSICAL AND CHEMICAL DATA (Nickel, Metallic)

A. Substance Identification

1. Synonyms: Nickel catalyst; Raney nickel
2. Formula: Ni
3. Molecular weight: 58.7

B. Physical Data

1. Boiling point (760 mm Hg): 2730 C (4946 F)
2. Specific gravity (water = 1): 8.9
3. Vapor density (air = 1 at boiling point of metallic nickel): Not applicable
4. Melting point: 1453 C (2648 F)
5. Vapor pressure at 20 C (68 F): Essentially zero
6. Solubility in water, % by weight at 20 C (68 F): Insoluble
7. Evaporation rate (butyl acetate = 1): Not applicable
8. Appearance and odor: Silvery gray, metallic (or darker), odorless powder

II. PHYSICAL AND CHEMICAL DATA (Nickel Nitrate Hexahydrate)

A. Substance Identification

1. Synonyms: None
2. Formula: $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$
3. Molecular weight: 290.8

B. Physical Data

1. Boiling point (760 mm Hg): 137 C (278 F) (loses water)
2. Specific gravity (water = 1): 2.05
3. Vapor density (air = 1 at boiling point of nickel nitrate hexahydrate): Not applicable
4. Melting point: 57 C (135 F)
5. Vapor pressure at 20 C (68 F): Essentially zero
6. Solubility in water, % by weight at 20 C (68 F): 60
7. Evaporation rate (butyl acetate = 1): Not applicable
8. Appearance and odor: Green, odorless solid

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III. PHYSICAL AND CHEMICAL DATA (Nickel Sulfate Hexahydrate)

A. Substance Identification

1. Synonyms: None
2. Formula: $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$
3. Molecular weight: 262.8

B. Physical Data

1. Boiling point: 103 C (217 F) (loses water)
2. Specific gravity (water = 1): 2.07
3. Vapor density (air = 1 at boiling point of nickel sulfate hexahydrate): Not applicable
4. Melting point: 53 C (127 F)
5. Vapor pressure at 20 C (68 F): Essentially zero
6. Solubility in water, % by weight at 20 C (68 F): 40
7. Evaporation rate (butyl acetate = 1): Not applicable
8. Appearance and odor: Green, odorless solid

IV. FIRE, EXPLOSION AND REACTIVITY HAZARD DATA

A. Fire

1. Flash point: Not applicable
2. Minimum ignition temperature: Not available
3. Minimum explosive concentration: Not available
4. Extinguishing media: Dry powder, dry sand, dry dolomite, dry graphite
5. Special fire-fighting procedures: Do not use a solid stream of water since a stream will scatter and spread the fire. Use water spray to cool containers exposed to a fire.
6. Unusual fire and explosion hazards: Nickel is a combustible solid. Its dust can form explosive mixtures with air. One form, nickel sponge catalyst ignites spontaneously in air. All ignition sources must be controlled where nickel is used, handled or stored in a manner that could create a potential fire or explosion hazard.

B. Reactivity

1. Conditions contributing to instability: Heat (nickel only.)
2. Incompatibilities: Contact of nickel with strong acids may form flammable and explosive hydrogen gas. Contact with sulfur may cause evolution of heat. Contact of nickel nitrate with wood and other combustibles may cause fire.
3. Hazardous decomposition products: Toxic gases and vapors (such as nickel carbonyl and oxides of nitrogen) may be released in a fire involving nickel or in the decomposition of nickel compounds.
4. Special precautions: None.

V. SPILL AND DISPOSAL PROCEDURES

A. If nickel metal or soluble nickel compounds are spilled, the following steps should be taken:

1. Ventilate area of spill.
2. Collect spilled material in the most convenient and safe manner for reclamation, or for disposal in a secured

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sanitary landfill. Liquid containing nickel should be absorbed in vermiculite, dry sand, earth or a similar material.

- B. Persons not wearing protective equipment should be restricted from areas of spills until cleanup has been completed.
- C. Waste disposal methods: Nickel metal and soluble nickel compounds may be disposed of in sealed containers in a secured sanitary landfill.

VI. MONITORING AND MEASUREMENT PROCEDURES

- A. EXPOSURE ABOVE THE ACTION LEVEL: Measurements taken for the purpose of determining employee exposure under this section are best taken such that the average eight-hour exposure may be determined from a single eight-hour sample or two four-hour samples. Several short time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). Sampling and analyses may be performed by instruments such as detector tubes certified by NIOSH under 42 CFR part 84, portable direct-reading instruments, dosimeters, or by collection of the particulates using a high efficiency membrane filter with subsequent chemical analyses. The method of measurement must determine the concentration of nickel metal and soluble compounds to plus or minus 35%.
- B. EXPOSURE ABOVE THE PERMISSIBLE EXPOSURE: The monitoring and measurements under this section should be essentially the same as described under paragraph IV. A. Laboratories performing chemical analyses should be accredited in Industrial Hygiene Chemistry by the American Industrial Hygiene Association. The method of measurement must determine the concentration of nickel metal and soluble compounds to plus or minus 25%.
- C. METHODS: Methods meeting these accuracy requirements are available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161 under the title "NIOSH Analytical Methods for Set N" (Order number XXXXXXXXXX).
- D. QUALIFIED PERSONS: Since many of the duties relating to employee protection are dependent on the results of monitoring and measuring procedures, employers should assure that the evaluation of employee exposures is performed by a competent industrial hygienist or other technically qualified person.

VII. MISCELLANEOUS PRECAUTIONS

- A. Store nickel metal and soluble nickel compounds in tightly closed containers in a cool, well ventilated area.
- B. Store Raney nickel catalyst under water or an inert gas.
- C. Employers should advise employees of all areas and operations where exposure to nickel metal and soluble nickel compounds could occur.

VIII. COMMON OPERATIONS

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Common operations in which exposure to nickel metal and soluble nickel compounds is likely to occur are: During the fabrication of nickel alloys; during the metallurgy of nickel and its conversion to various alloys and alloyed materials; during the preparation and use of nickel catalysts, such as Raney nickel; during the production of nickel compounds; during the use of nickel compounds in nickel plating solutions, as an ingredient in ceramic colors, in nickel-cadmium batteries, and in the preparation of nickel catalysts; during chemical synthesis; and in the textile industry.

APPENDIX C - MEDICAL SURVEILLANCE GUIDELINES

I. ROUTE OF ENTRY

Inhalation.

II. TOXICOLOGY

Metallic nickel and certain soluble nickel compounds as dust or fume cause sensitization dermatitis and probably produce cancer of the paranasal sinuses and the lung; nickel fume in high concentrations is a respiratory irritant. Severe but transient pneumonitis in 2 workers resulted from exposure to nickel fume; in one case, exposure was for 6 hours and postincident sampling suggested a nickel concentration of 0.26 mg/M3. "Nickel itch" is a dermatitis resulting from sensitization to nickel; the first symptom is usually itching which occurs up to 7 days before skin eruption appears. The primary skin eruption is erythematous, or follicular; it may be followed by superficial discrete ulcers, which discharge and become crusted, or by eczema; in the chronic stages, pigmented or depigmented plaques may be formed. Nickel sensitivity, once acquired, is apparently not lost; recovery from the dermatitis usually occurs within 7 days of cessation of exposure but may take several weeks. A worker who had developed cutaneous sensitization also developed apparent asthma from inhalation of nickel sulfate; immunologic studies showed circulating antibodies to the salt, and controlled exposure to a solution of nickel sulfate resulted in decreased pulmonary function and progressive dyspnea; the possibility of developing hypersensitivity pneumonitis could not be excluded. In animals, finely divided metallic nickel was carcinogenic when introduced into the pleural cavity, muscle tissue, and subcutaneous tissues; rats and guinea pigs exposed to a concentration of 15 mg/M3 of powdered metallic nickel developed malignant pulmonary neoplasms. Several epidemiologic studies have shown an increased incidence of cancer of the paranasal sinuses and lungs among workers in nickel refineries and factories; suspicion of carcinogenicity has been focused primarily on respirable particles of nickel, nickel subsulfide, nickel oxide, and on nickel carbonyl vapor. Many of the studies also included exposures to other suspected carcinogens.

III. SIGNS AND SYMPTOMS

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Sensitization dermatitis; cancer of the lungs and nasal cavities; pneumonitis; possible allergic asthma.

IV. SPECIAL TESTS

None in common usage. Consideration may be given to the value of sputum cytologies.

V. TREATMENT

Remove from exposure. Immediately flush eyes and skin with water. If swallowed and the person is conscious, induce vomiting. Give artificial resuscitation if indicated. Consideration should be given to hospitalization and observation for the possible delayed onset of pulmonary edema. Recovery is usually complete. Consideration may be given to the use of corticosteroids.

VI. SURVEILLANCE AND PREVENTIVE CONSIDERATIONS

A. GENERAL

Nickel and soluble nickel compounds cause sensitization dermatitis and at high concentrations nickel fume causes acute pneumonitis. Nickel and certain nickel compounds cause cancer of the nasal cavities and the lungs. It is important that the physician become familiar with plant operating conditions in which exposure to nickel occurs. Those with skin disease may not tolerate the wearing of protective clothing and those with chronic respiratory disease may not tolerate the wearing of negative pressure respirators.

B. PREPLACEMENT

The following medical procedures must be made available to each employee who is exposed to nickel:

1. A complete history and physical examination -- The purpose is to detect preexisting conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a history of asthma, allergies, or known sensitization to nickel and soluble nickel compounds would be expected to be at increased risk from exposure. Examination of the nasal cavities and lungs should be stressed. The skin should be examined for evidence of chronic disorders.
2. 14" x 17" chest roentgenogram -- Nickel and soluble nickel compounds cause human lung damage and cancer of the lung. Surveillance of the lungs is indicated.

C. PERIODIC EXAMINATIONS

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The above medical examinations are to be repeated on an annual basis.

VII. REFERENCES

1. American Conference of Governmental Industrial Hygienists: "Nickel Ni," Documentation of the Threshold Limit Values for Substances in Workroom Air (3d ed., 2d printing), Cincinnati, 1974, pp. 178-179.
2. Hygienic Guide Series: "Nickel (Except the Carbonyls)," American Industrial Hygiene Association Journal, 27:202-205, 1966.
3. Patty, Frank A.: Industrial Hygiene and Toxicology, Vol. II - Toxicology (2d ed. revised), Interscience Publishing Company, New York, 1963, pp. 1118-1122.
4. Browning, Ethel: Toxicity of Industrial Metals, (2d ed.), Butterworths, London, 1969, pp. 249-260.
5. McConnell, L.H., et al: "Asthma Caused by Nickel Sensitivity," Annals of Internal Medicine, 78:888-890, 1973.
6. Committee on Medical and Biologic Effects of Environmental Pollutants, Division of Medical Sciences, National Research Council: Nickel, National Academy of Sciences, Washington, D.C., 1975, pp. 144-188, 231-268.

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REFERENCES AND SOURCES
NICKEL METAL AND SOLUBLE SALTS
1910.93

(f) Personal Protective Equipment, and (h) Sanitation

Eye: "Nickel," Hygienic Guide Series

Skin: Documentation of Threshold Limit Values

Hamilton and Hardy, "Industrial Toxicology"

Van Oettingen, "Poisoning"

Browning, "Toxicity of Industrial Metals"

Patty, "Industrial Hygiene and Toxicology"

National Academy of Sciences, "Medical and Biologic Effects of Environmental Pollutants, Nickel"

Ingestion: "Nickel," Hygienic Guide Series

Gleason, "Clinical Toxicology of Commercial Products"

Browning, "Toxicity of Industrial Metals"

Patty, "Industrial Hygiene and Toxicology"

COMMENTS

Eye - Classification: 0

Output statement numbers: None

Exceptions: None

A search of the literature failed to reveal information on properties of either metallic nickel or its soluble compounds which with the eye. The Hygienic Guides Series report no eye problems with nickel.

According to Grant, "workers employed in nickel plating involving sulfate, sulfuric acid and chlorine, are said to have developed conjunctivitis and epiphora when ventilation was poor."

It is doubtful that all soluble compounds of nickel are harmful to the eye, but the lack of any firm indication in the literature that nickel is harmful leads to the conclusion that a classification of zero is specified.

Skin - Classification: 2 and 6

Output statement numbers: 2, 5b, 7a, 17g, 17i, 20a

Exceptions: None

Nickel and its salts are not absorbed through the skin in an amount sufficient to cause intoxication, but they commonly produce a sensitization reaction dermatitis - nickel itch - in humans. The Documentation of Threshold Limit Values reports "dermatitis, nickel itch . . . to have two components, a simple dermatitis localized to the area of contact and eczema or neurodermatitis without apparent connection with such contact, i.e., systemic in origin." According to Hamilton and Van Oettingen, "the eczema comes first on the worker's arms and if he is not removed (from the exposure) it will spread to his neck and legs or to his whole body." They comment, "that if a man has been once affected he is practically sure to have another attack which comes on more promptly the first, with lesions that heal slowly." They also note itching, burning and edema of affected areas. They found that cases in which the eruption extends over a considerable portion of the body can be very serious and require hospital care. Von Oettingen comments that "the initial stage of itching and burning, dermatitis develops which is characterized by small papular and vesicular efflorescences of exanthematous character . . . (and) often there are weeping areas and small pyrexia."

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with impetigo formation and in severe cases of necrotic areas." notes that eruption may occur after a latent period of 8-10 days sometimes 3-4 weeks and may last from several weeks to several months. Citing the studies of Girard and Thevemard, Browning reports, "the characteristic lesions of nickel itch are ushered in by itching, sometimes lasts a week before the eruption appears." She adds that eruptions . . . may be followed by superficial discrete ulcers which charge and become crusted over or by eczema . . . (and) in chronic pigmentation or depigmentation plaques may be found." Patty states nickel itch may be accompanied by fever.

The National Academy of Sciences has reported that in studies by Fisher, "nickel causes more instances of contact dermatitis than metals put together. He ranked nickel compounds (as a group) as third highest index of sensitization."

Classifications of 2 and 6 are concluded to be appropriate for "metallic nickel" and soluble compounds of nickel. Massive forms though capable of causing the cited local effects in susceptible are not considered to be of sufficient hazard to warrant their inclusion in the standard.

Ingestion - Classification: 1 and 5

Output statement numbers: 19, 20a

Exceptions: None

The Hygienic Guide Series found metallic nickel to have a low oral toxicity and the soluble salts to have a high one and in large doses latter cause giddiness and nausea. Gleason classifies nickel salts "very toxic" (toxicity class 4 out of 6), corresponding to a probable human lethal dose of 50-500 mg/kg or between 1 tsp and 1 ounce which would prove fatal for the average 150 lb man. He also notes that the severe effects which may follow oral administration of nickel salts include capillary damage (especially in the brain and adrenals), renal impairment, myocardial weakness and central nervous depression. Browning comments that "metallic nickel and its soluble salts are toxic to animals in large doses but rarely produce systemic toxic effects in human beings." The toxicity to animals of large doses of nickel salts caused acute gastrointestinal irritation with vomiting and diarrhea and Greco estimates a lethal dose for dogs at 0.5 g. Lehman recorded that 6-12 mg of nickel for 100-200 days of chloride and sulfate in the form of acetate caused significant injury. Patty adds that severe damage to myocardium and parenchyma of rabbits drinking water containing nickel sulfate equivalent to 0.54 mg/kg for 160 days has been noted.

Classifications of 1 and 5 are concluded to be warranted for soluble compounds of nickel.

SUBSTANCE TECHNICAL GUIDELINES

The references cited for this document include:

Harshaw Chemical Co., Bulletin 71874 (Harsh)

McGean Chemical Co., Material Safety Data Sheet (McG)

Tenneco Chemicals, Inc., Material Safety Data Sheet (Tenn)

Kirk-Othmer, "Encyclopedia of Chemical Technology," Vol. 13, p. 735 (K-O)

National Fire Protection Association, "Fire Protection Guide on Hazardous Materials," 5th edition, 1975 (NFPA)

"Lange's Handbook of Chemistry," 11th edition (Lange)

Sources of data items used:

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- I. A. 1. Synonyms: NFPA-49, McG
2. Formula: McG
3. Molecular weight: K-O, Lange, Tenn
- B. 1. Boiling point: K-O, Lange
2. Specific gravity: McG, K-O, Tenn
3. Vapor density: Not applicable
4. Melting point: K-O, Lange
5. Vapor pressure: ADL
6. Solubility in water: McG, Tenn
7. Evaporation rate: Not applicable
8. Appearance and odor: NFPA-49, McG, Tenn
- II. A. 1. Flash point: Not applicable
2. Minimum ignition temperature: Not available
3. Minimum explosive concentration: Not available
4. Extinguishing media: NFPA-49
5. Special fire fighting procedures: NFPA-49
6. Unusual fire and explosion hazards: NFPA-49, ADL
- B. 1. Conditions contributing to instability: ADL
2. Incompatibilities: NFPA-49, 491M
3. Hazardous decomposition products: NFPA-49, McG
4. Special precautions: None
- III. A. Steps if released or spilled: McG, Tenn, ADL
C. Waste disposal method: McG, Tenn
- V. Miscellaneous precautions: NFPA-49

USE/EXPOSURE AND CONTROL DOCUMENT

References used in the preparation of this document include:

- Considine, D. M., "Chemical and Process Technology Encyclopedia," McGraw - Hill, 1974 (Considine)
- Hawley, G. G., "The Condensed Chemical Dictionary," Van Nostrand - Reinhold Co., 8th edition, 1971 (Hawley)
- International Labour Office, "Encyclopedia of Occupational Health and Safety," 1972 (ILO)
- Kirk, R. and Othmer, D., "Encyclopedia of Chemical Technology," Interscience Publishers, 2nd edition, 1972 (K-O)
- "Nickel," Hazard Process Index, Hazard Entry No. 133, NIOSH HSM-99-73-62 (HPI)
- "Nickel," Hygienic Guide Series, American Industrial Hygienists Association, March - April 1966 (Hygienic Guide)
- Patty, F. A., "Industrial Hygiene and Toxicology," Vol. II, Interscience Publishers, 1962 (Patty)
- Schwartz, L., Tulipan, L. and Birmingham, D. J., "Occupational Diseases of the Skin," Lea and Febiger, 3rd edition, 1957 (Schwartz)
- Stanford Research Institute, "Chemical Economics Handbook," Menlo Park, California (SRI)

References for Specific Use/Exposures

- 1. Considine, HPI, Hygienic Guide, ILO, Patty
- 2. Considine
- 3. HPI, K-O
- 4. HPI, K-O
- 5. K-O, Patty
- 6. K-O, Patty
- 7. Hawley, Hygienic Guide
- 8. ILO, SRI

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9. Hawley, K-O

10. Hawley

References for Specific Control Methods

1. Schwartz

2. Schwartz

3. Hygienic Guide

4. Hygienic Guide

5. Schwartz

6. Schwartz

Hygienic Guide was the reference used in numbers 7 - 10 of the Specific Control Methods.

RESPIRATOR TABLE DOCUMENTATION

SUBSTANCE: Nickel metal and soluble compounds

D. O. L. STANDARD: 1 mg/M3

Eye Irritation Level: Grant states that "workers employed in nickel plating involving nickel sulfate, sulfuric acid, and chlorine are said to have developed conjunctivitis and epiphora when ventilation was poor." Since, according to Grant, "both sulfuric acid mist and chlorine gas are known to cause burning and stinging of the eyes," and since the AIHA Hygienic Guides state that eye contact "does not present any problem peculiar to nickel," nickel metal and soluble compounds are not treated as eye irritants.

IDLH: The available toxicological information does not indicate that exposure to a high concentration of nickel metal or soluble nickel compounds could impede escape within one-half hour. For the purposes of this standard, therefore, respirators have been assigned on the basis of the protection factor afforded by each device.

Other Toxicological Information: Browning states that "metallic nickel and its soluble salts, while toxic to animals in large doses, have rarely produced systemic toxic effects in human beings even from therapeutic administration. They are important from the industrial point of view only for their capacity for causing dermatitis. Patty also states that "apart from the possible malignant effects of $\text{Ni}(\text{CO})_4$ dermatitis constitutes the only other serious Ni exposure hazard. Numerous cases of dermatitis have been reported among Ni platers."

The Documentation of TLV's, however, reports that "an increase in nasal, sinus and lung cancer was noted in workers employed in nickel refineries. The specific carcinogenic agent is still not defined and is the subject of continuing research. Finely divided metallic nickel when introduced into the pleural cavity, muscle tissue and subcutaneous tissue of animals has been shown to be carcinogenic. Dust from the effluent stack of an Ontario refinery containing chiefly nickel sulfide, nickel sulfate and nickel oxide was shown to be a local acting carcinogen. Hueper reported in 1958 that rats and guinea pigs exposed to a concentration of 15 mg/M3 of powdered metallic nickel developed malignant pulmonary neoplasms . . . In Great Britain, cancer of the nose, sinus, bronchus and lung has been recognized as an occupational disease in workmen employed in any process where nickel is produced by the "decomposition of a gaseous nickel compound." However, cases of lung cancer have also been reported from Norway where the nickel carbonyl process was not

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in use. A significant increase in both sinus and lung cancer has been noted in Ontario workmen exposed to mixed nickel dusts in certain furnace operations involving oxidation of nickel sulfide. No cases of sinus cancer and no excess of lung cancer have been reported in Great Britain among workers employed since 1925.

"Despite the reports noted above, documentation of air concentrations of nickel and its compounds encountered in industrial operations is scarce. Friberg in 1948 noted air concentrations for nickel dust ranging from 10 to 700 mg/M3 in a Swedish alkali storage battery industry. The role of nickel in the production of the health effects he reported in workers with long exposure - namely proteinuria, impaired kidney function and pulmonary emphysema - is open to question because of concomitant exposure to cadmium dust by these persons. At the present time, dust concentrations below 5 mg/M3 are found in an Ontario refinery. (This dust contains mainly nickel and cobalt.) The concentrations associated with the increase in respiratory cancer in Great Britain and in Ontario were considerably in excess of the present levels . . .

"A threshold limit value of 1 mg/M3 is recommended for nickel dust or fume and soluble nickel salts; epidemiologic evidence suggests that the hazard presented by insoluble nickel compounds is not so great. The limit is probably not sufficiently low to prevent dermatitis of sensitization from soluble salts and mists . . ." An additional reference is the National Academy of Science Monograph entitled, NICKEL".

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USE/EXPOSURE AND CONTROL DOCUMENT
NICKEL METAL AND SOLUBLE COMPOUNDS

	Use/Exposure	Principal Route of Entry	Currently Used Control Methods
1.	Inhalation of dust or fume and skin contact with dust or metal during the fabrication of nickel alloyed materials (polishing, welding, cutting, grinding, casting, plasma arc). There are more than 3000 alloys of nickel. It aids corrosion and heat resistance, enhances ductibility and increases thermal conductivity. The number of products made from nickel alloys is endless -- electronic tube parts, coins, heavy machinery, tools, instrument parts, magnets, food and chemical processing equipment, flatware, jet engines, automotive parts, zippers, nickel anodes, surgical and dental instruments, cooking utensils, etc)	A,B	General dilution ventilation; local exhaust ventilation; personal protective equipment (respiratory protective devices, protective clothing)
2.	Inhalation of dust and skin contact with dust during the processing and refining of nickel (most nickel mined and processed in this country is the sulfide ore). The crude ore is crushed and ground - separated by beneficiation, flotation and magnetism - producing an enriched ore. The enriched ore is refined by the Mond Process or electrolytic process. Nickel is available in pellets, powder, briquettes, ingots, shot and electrolytic sheets (1 sq. in. to 1 sq. yd.).	A,B	General dilution ventilation; local exhaust ventilation; personal protective equipment (gloves, coveralls, aprons, boots, respiratory protective devices)
3.	Inhalation of dust and fume during the manufacture of nickel-iron alloys (cast iron, steels, stainless steel,	A	Local exhaust ventilation; general dilution ventilation

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wrought alloy steel, alloy cast irons, magnetic alloys, strength steels, magnetic compensator alloys, thermal expansion alloys, thermoelastic alloys, etc.)

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| 4. | Inhalation of dust and fume during the manufacture of nonferrous-nickel alloys. Nickel may be alloyed with copper, chromium, aluminum, molybdenum, manganese, silver, etc., to make super-alloys, bearing alloys, low expansion alloys, heat resisting alloys, brasses, bronzes, nickel silvers, etc. | A | Local exhaust ventilation; general dilution ventilation |
| 5. | Inhalation of dust or fume and skin contact with dust or metal during the fabrication of nickel plated materials (radio and electronic tube parts, sewing needles, automobile door handles and bumpers, jewelry, decorative and protective coatings) | A,B | General dilution ventilation; local exhaust ventilation; personal protective equipment (respiratory protective devices, protective clothing) |
| 6. | Inhalation of mist and skin contact with liquid or metal during use of nickel and nickel salts in the plating industry - electroplating and electroless (chemical) plating. Nickel can be plated as a protective or decorative coating and as an undercoat to chromium plating. It is plated in all thicknesses - from a flash to several millimeters. Plating industry makes use of nickel anodes, nickel sulfate, nickel ammonium sulfate, nickel-phosphate and nickel chloride. | A,B | General dilution ventilation; local exhaust ventilation; personal protective equipment (goggles, gloves, coveralls, aprons, boots) |
| 7. | Inhalation of dust and skin contact with metal or soluble compound during use | A,B | General dilution ventilation |

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in chemical synthesis.
Nickel is used as the starting material in the synthesis of most nickel compounds. The soluble nickel compounds are used as intermediates in the synthesis of more complex compounds (mainly nickel catalysts)

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| 8. | Inhalation of dust and skin contact with metal during use of nickel as a catalyst (hydrogenation of fats and oils, production of cyclohexanol from phenol) | A,B | General dilution ventilation |
| 9. | Inhalation of mist and skin contact with liquid during use of soluble nickel compounds in the textile industry - mordant in dyeing and printing, fixatives for polypropylene fibers (nickel acetate, nickel sulfate, nickel ammonium chloride) | A,B | General dilution ventilation; local exhaust ventilation |
| 10. | Inhalation of dust and skin contact with crystals or solution of soluble compounds during use in the ceramics industry (nickel nitrate, nickel sulfate). The nickel compound is usually used in relation to the color or coloring of ceramics. | A,B | General dilution ventilation; local exhaust ventilation |

A -- Inhalation

B -- Skin and eye contact resulting in localized irritation

C -- Ingestion

D -- Skin contact resulting in absorption and subsequent systemic poisoning