Occupational Health Guideline for Cadmium Fume

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: Cd/CdO
- Synonyms: None
- Appearance: Finely divided solid particles dispersed in air.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for cadmium fume is 0.1 milligram of cadmium fume per cubic meter of air (mg/m³) averaged over an eight-hour work shift, with an acceptable ceiling level of 0.3 mg/m³. NIOSH has recommended that the permissible exposure limit be reduced to a time-weighted average of 40 micrograms cadmium per cubic meter (ug/m³) with a ceiling level of 200 ug cadmium/m³ for a 15-minute period. The NIOSH Criteria Document for Cadmium should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Cadmium fume can affect the body if it is inhaled.

- **Effects of overexposure**

1. Short-term Exposure: Cadmium fume causes irritation of the nose and throat. If enough has been inhaled, after a delay of several hours, a person may also develop cough, chest pain, sweating, chills, shortness of breath, and weakness. Death may occur.

2. Long-term Exposure: Repeated or prolonged exposure to cadmium fume may cause loss of sense of smell, ulceration of the nose, shortness of breath (emphysema), kidney damage, and mild anemia. Exposure to cadmium fume has also been reported to cause an increased incidence of cancer of the prostate in men. Injections of cadmium sulfate in animals have been reported to cause malformation in their offspring. This effect has not been reported in humans.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to cadmium fume.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to cadmium fume at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the respiratory system, kidneys, and blood should be stressed.

—Urinalysis: Since kidney damage has been observed in humans exposed to cadmium, a urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment. The urine should be examined for the specific protein.

—14" x 17" chest roentgenogram: Cadmium causes human lung damage. Surveillance of the lungs is indicated.

—Liver function tests: Cadmium may cause liver damage. A profile of liver function should be obtained by utilizing a medically acceptable array of biochemical tests.

—FVC and FEV (1 sec): Cadmium is reported to cause decreased pulmonary function. Periodic surveillance is indicated.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis, except that an x-ray is necessary only when indicated by the results of pulmonary function testing.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

Urine protein measurements should be made available every four months.

• **Summary of toxicology**

Cadmium fume (cadmium oxide) is a severe pulmonary irritant that has caused fatal pulmonary edema in workers; chronic exposures may lead to severe pulmonary emphysema. Cadmium sulfide produces malignant tumors in animals by injection, suggesting that cadmium is carcinogenic. Most acute intoxications have been caused by inhalation of cadmium fume at concentrations which did not provide warning symptoms of irritation. The average concentrations of fume responsible for fatalities have been 40 to 50 mg/m³ for 1 hour, or 9 mg/m³ for 5 hours. Non-fatal pneumonitis has been reported from concentrations of 0.5 to 2.5 mg/m³, while relatively mild cases have been attributed to even lower concentrations. Following an asymptomatic latent period of 4 to 10 hours, there is characteristically nasopharyngeal irritation, followed by a feeling of chest constriction or substernal pain, with cough and dyspnea; there also may be headache, chills, muscle aches, nausea, vomiting, and diarrhea. Pulmonary edema may then develop rapidly, with decreased vital capacity and markedly reduced carbon monoxide diffusing capacity. In about 20% of the cases the dyspnea is progressive, accompanied by wheezing or hemoptysis, and may result in death within 7 to 10 days of exposure; at autopsy the lungs are markedly congested, and there is an intra-alveolar fibrinous exudate, as well as alveolar cell metaplasia. Among survivors, the subsequent course is unpredictable: most cases resolve slowly, but respiratory symptoms may linger for several weeks, while impairment of pulmonary function may persist for months. In experimental animals, cadmium exposure has caused pulmonary fibrosis, but this has not been documented in humans. In one fatal human case, in addition to lung abnormalities, there was renal cortical necrosis. Continued exposure to lower levels of cadmium in air has resulted in chronic poisoning characterized by irreversible lung injury of emphysematous type, with abnormal lung function and urinary excretion of a specific low-molecular-weight protein which may be associated with evidence of renal dysfunction. Clinical evidence of the cumulative effects of cadmium may appear after exposure has terminated; the disease then tends to be progressive. The frequency of occurrence of proteinuria increases with length of exposure: those exposed to cadmium compounds for less than 2 years had no proteinuria, whereas most of those exposed for 12 years or more had proteinuria with little other evidence of renal damage. Cadmium absorbed by any route is, to a very large extent, retained by the body. Excretion is very slow. The urinary excretion of cadmium bears no known relationship to the severity or duration of exposure and is only a confirmation of absorption. Other consequences of cadmium exposure are rhinitis, occasional ulceration of the nasal septum, damage to the olfactory nerve, and anosmia. The long-term ingestion of beans, rice and water contaminated with cadmium has been proposed as the probable cause of a crippling condition among Japanese women who have had multiple pregnancies; pain in the back and joints, an unsteady gait, osteomalacia, bone fractures, and occasional renal failure are characteristics of the disorder. Rats, injected subcutaneously with cadmium metal suspended in fowl serum, produced rhabdomyosarcomata; with cadmium sulfate in sterile distilled water, sarcomata; and with cadmium chloride solution, pleomorphic sarcomas at the injection site, suggesting that cadmium is carcinogenic. Cadmium sulfate injected into the lingual vein of female hamsters on day 8 of pregnancy caused a high incidence of resorption and malformed offspring. Increased prostatic and lung cancer has been reported in humans exposed to cadmium oxide. Acute necrosis of the rat testis follows large doses orally or parenterally.

CHEMICAL AND PHYSICAL PROPERTIES

• **Physical data**

1. Molecular weight: 112— 128
2. Boiling point (760 mm Hg): Not applicable
3. Specific gravity (water = 1): Not applicable
4. Vapor density (air = 1 at boiling point of cadmium fume): Not applicable
5. Melting point: Not applicable
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Reactivity**

1. Not applicable

• **Flammability**

1. Not applicable

• **Warning properties**

Grant reports that "smarting of the eyes occurs relatively infrequently (upon exposure to cadmium fume), and no injury to the eyes of human beings has been reported. Neither eye nor respiratory tract irritation is enough to prevent exposures which may cause serious systemic poisoning and damage to the lungs."

MONITORING AND MEASUREMENT PROCEDURES

• **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on 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).

• **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected

airborne concentrations of cadmium fume. Each measurement should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• **Method**

Sampling and analyses may be performed by collection of cadmium fume on a cellulose membrane filter, followed by treatment with nitric acid, solution in acid, and analysis with an atomic absorption spectrophotometer. An analytical method for cadmium fume is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

SANITATION

• Eating and smoking should not be permitted in areas where fumes may be generated in the handling or processing of cadmium.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to cadmium fume may occur and control methods which may be effective in each case:

Operation	Controls
Liberation during smelting and refining of ores where it is a by-product of zinc, lead, and copper-bearing ores	Process enclosure; local exhaust ventilation; personal protective equipment
Liberation during recovery of metal by processing of scrap; during melting and pouring of cadmium metal; during casting of alloys for cadmium-copper, cadmium-lead, cadmium-bismuth, cadmium-silver, cadmium-nickel, cadmium-lead-silver, cadmium-lead-silver-nickel, cadmium-lead-bismuth-tin, and cadmium-gold products used for coating telephone cables, trolley wires, welding electrodes, automatic sprinkling systems, steam boilers, fire alarms, high-pressure/temperature bearings, starting switches, aircraft relays, light-duty circuit breakers, low-temperature solder, and jewelry	Process enclosure; local exhaust ventilation; personal protective equipment
Liberation during fabrication of metal, alloys, or plated steel	Process enclosure; local exhaust ventilation; personal protective equipment
Liberation during casting and use of solders; during melting of cadmium ingots for paint and pigment manufacture used for coloring of plastics and ceramic glazes, electroplating, and in chemical synthesis	Process enclosure; local exhaust ventilation; personal protective equipment
Liberation during coating on metals by hot dipping or spraying	Process enclosure; local exhaust ventilation; personal protective equipment

Liberation during manufacture of nickel-cadmium batteries for use in radio-portable telephones, convenience appliances, and vented cells used in air planes, heliocopters, and stand-by power and lighting	Process enclosure; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• **Breathing**

If a person breathes in large amounts of cadmium fume, 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.

• **Rescue**

Move the 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. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of releases until cleanup has been completed.

• If potentially hazardous amounts of cadmium fume are inadvertently released, ventilate the area of the release to disperse the fume.

REFERENCES

• American Conference of Governmental Industrial Hygienists: "Cadmium and Compounds as Cd," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

• American Industrial Hygiene Association: "Cadmium," *Hygienic Guide Series*, Detroit, Michigan, 1963.

• Bonnell, J. A.: "Cadmium Poisoning," *Annals of Occupational Hygiene*, 8:45-50, 1965.

• Browning, E.: *Toxicity of Industrial Metals* (2nd ed.), Butterworths, London, 1969.

• Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.

• Dunphy, B.: "Acute Occupational Cadmium Poisoning: A Critical Review of the Literature," *Journal of Occupational Medicine*, 9:22-26, 1967.

• Emmerson, B. T.: "'Ouch-Ouch' Disease: The Osteomalacia of Cadmium Nephropathy," *Annals of Internal Medicine*, 73:854-855, 1970.

• Fassett, D. W.: "Cadmium: Biological Effects and Occurrence in the Environment," *Annual Review of Pharmacology*, 15:425-435, 1975.

• Fleischer, M., et al.: "Environmental Impact of Cadmium: A Review by the Panel on Hazardous Trace Substances," *Environmental Health Perspectives*, 253-323, May 1974.

• Friberg, L., et al.: *Cadmium in the Environment*, (2nd ed.), CRC Press, Cleveland, 1974.

• Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.

• Gunn, S. A., et al.: "Specific Response of Mesenchymal Tissue to Cancerigenesis by Cadmium," *Archives of Pathology*, 83:493-499, 1967.

• Haddow, A., et al.: "Cadmium Neoplasia: Sarcomata at the Site of Injection of Cadmium Sulphate in Rats and Mice," *British Journal of Cancer*, 18:667-673, 1964.

• Heath, J. C., et al.: "Cadmium as a Carcinogen," *Nature*, 193:592-593, 1962.

• Holmberg, E. R., Jr., and Ferm, V. H.: "Interrelationships of Selenium, Cadmium, and Arsenic in Mammalian Teratogenesis," *Archives of Environmental Health*, 18:873-877, 1969.

• Louria, D. B., et al.: "The Human Toxicity of Certain Trace Elements," *Annals of Internal Medicine*, 76:307-319, 1972.

• National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . . Occupational Exposure to Cadmium*, HEW Publication No. (NIOSH) 76-192, GPO No. 017-033-00206-1, U.S. Government Printing Office, Washington, D.C., 1976.

• Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.

• Tsuchiya, K.: "Proteinuria of Workers Exposed to Cadmium Fume," *Archives of Environmental Health*, 14:875-880, 1967.

* SPECIAL NOTE

The International Agency for Research on Cancer (IARC) has evaluated the data on this chemical and has concluded that it causes cancer. See *IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man*, Volume 2, 1973, and Volume 11, 1976.

RESPIRATORY PROTECTION FOR CADMIUM FUME

Condition	Minimum Respiratory Protection* Required Above 0.1 mg/m³
Particulate Concentration	
1 mg/m³ or less	Any fume respirator or high efficiency particulate respirator. Any supplied-air respirator. Any self-contained breathing apparatus.
5 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.
40 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.
Greater than 40 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.
Escape	A high efficiency particulate filter respirator with a full facepiece. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.