

# Occupational Health Guideline for Fluoride Dust (as Fluoride)

## 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.

## APPLICABILITY

The general guidelines contained in this document apply to all fluoride. Physical and chemical properties of several specific compounds are provided for illustrative purposes.

## SUBSTANCE IDENTIFICATION

### Sodium fluoride

- Formula: NaF
- Synonyms: None
- Appearance and odor: Colorless or blue, odorless solid.

### Cryolite (sodium hexafluoroaluminate)

- Formula:  $\text{Na}_3\text{AlF}_6$
- Synonyms: Sodium hexafluoroaluminate
- Appearance and odor: Colorless to dark, odorless solid.

## PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for fluoride is 2.5 milligrams of fluoride per cubic meter of air ( $\text{mg}/\text{m}^3$ ) averaged over an eight-hour work shift. NIOSH has recommended that the permissible exposure limit be changed to 2.5  $\text{mg}/\text{m}^3$  averaged over a work shift of up to 10 hours per day, 40 hours per week. The NIOSH Criteria Document for Inorganic Fluorides should be consulted for more detailed information.

## HEALTH HAZARD INFORMATION

### • Routes of exposure

Fluoride can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed.

### • Effects of overexposure

1. *Short-term Exposure:* Fluoride containing dust may cause irritation of the eyes and respiratory tract. Swallowing fluoride may cause a salty or soapy taste, vomiting, abdominal pain, diarrhea, shortness of breath, difficulty in speaking, thirst, weakness of the pulse, disturbed color vision, muscular weakness, convulsions, loss of consciousness, and death. Kidney injury and bleeding from the stomach may occur.

2. *Long-term Exposure:* Repeated exposure to fluoride containing dust may cause excessive calcification of the bone and calcification of ligaments of the ribs, pelvis, and spinal column. Stiffness and limitation of motion may result. Repeated or prolonged exposure of the skin to fluoride containing dust may cause a skin rash.

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 fluoride.

### • Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to fluoride 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 eyes, respiratory tract, central nervous system, skeletal system, and the kidneys should be stressed. The skin should be examined for evidence of chronic disorders.

—Urinalysis: Since kidney disease interferes with excretion of fluoride, thus increasing the risk from exposure to excessive fluoride, a urinalysis should be

---

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

obtained to include, at a minimum, specific gravity, albumin, glucose, and a microscopic examination on centrifuged sediment. An analysis for fluoride should be performed.

—Pelvic roentgenogram: Fluoride causes skeletal abnormalities. A radiologic examination of the male pelvis with proper gonadal shielding should be conducted at the time of the preplacement examination and when indicated by analysis of the results of the urinary fluoride tests.

—Eye disease: Fluoride is an eye irritant and may cause tissue damage. Those with pre-existing eye problems may be at increased risk from exposure.

—14" x 17" chest roentgenogram: Fluoride may cause respiratory system effects, such as fibrosis and asthma. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Fluoride is a respiratory irritant. Persons with impaired pulmonary function may be at increased risk from exposure. Periodic surveillance is indicated.

—Skin disease: Fluoride can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

**2. Periodic Medical Examination:** The aforementioned medical examinations should be repeated on an annual basis, except that the radiologic examination of the pelvis should be conducted only when clinically indicated.

#### • Summary of toxicology

Fluoride causes irritation of the eyes and respiratory tract; absorption of excessive amounts of fluoride over a long period of time results in increased radiographic density of bone. The lethal oral dose of sodium fluoride for humans is approximately 5 g; effects are diffuse abdominal pain, diarrhea, and vomiting; excessive salivation, thirst, and perspiration; painful spasms of the limbs; and sometimes albuminuria. Workers exposed to an airborne fluoride concentration of 5 mg/m<sup>3</sup> complained of eye and respiratory tract irritation and nausea. A portion of absorbed fluoride is stored in bone and part is excreted promptly in the urine; with continued exposure and increasing amounts of fluoride already present in the bone, the fraction appearing in the urine increases. Some storage of fluoride occurs from the ingestion of as little as 3 mg/day. Repeated exposure to excessive concentrations of fluorides over a period of years results in increased radiographic density of bone and eventually may cause crippling fluorosis (osteosclerosis due to deposition of fluoride). The gross changes in the skeleton are quite distinctive and characteristic; as the amount of fluoride in the bone increases, exostoses may develop, especially on the long bones; the spinal and pelvic ligaments begin to calcify, occasionally vertebrae fuse together, and a typical stiffness of the spinal column develops. The absorption of 20 to 80 mg of fluoride daily may be expected to lead to crippling fluorosis in 10 to 20 years; this condition has not been reported in the United States from industrial

exposure. Evidence from several sources indicates that urinary fluoride concentrations not exceeding 5 mg/l in pre-shift samples taken after 2 days off work are not associated with detectable osteosclerosis and that such changes are unlikely at urinary levels of 5 to 8 mg/l. Repeated or prolonged exposure of the skin to fluoride-bearing dusts and fumes may cause dermatitis. Mottled appearance and altered form of teeth are most pronounced when excessive amounts of fluoride are ingested during the period of formation and calcification of teeth, which occurs during the first 8 years of life in humans; after the teeth erupt and calcification has been completed, fluoride does not have an adverse effect on the teeth.

## CHEMICAL AND PHYSICAL PROPERTIES

### • Physical data—Sodium fluoride

1. Molecular weight: 42
2. Boiling point (760 mm Hg): 1702 C (3095 F)
3. Specific gravity (water = 1): 2.8
4. Vapor density (air = 1 at boiling point of sodium fluoride): Not applicable
5. Melting point: 992 C (1818 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): 4.2
8. Evaporation rate (butyl acetate = 1): Not applicable

### • Physical data—Cryolite (sodium hexafluoroaluminate)

1. Molecular weight: 209.9
2. Boiling point (760 mm Hg): Decomposes
3. Specific gravity (water = 1): 2.8
4. Vapor density (air = 1 at boiling point of cryolite): Not applicable
5. Melting point: 1009 C (1848 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): 0.04
8. Evaporation rate (butyl acetate = 1): Not applicable

### • Reactivity

1. Conditions contributing to instability: None
2. Incompatibilities: Contact with strong acids may cause formation of toxic and irritating hydrogen fluoride gas.
3. Hazardous decomposition products: None
4. Special precautions: None

### • Flammability

1. Not combustible

### • Warning properties

Concerning fluorides, Grant states that "industrially, fluorides may contact the eyes in the form of fumes from fluxes in soldering, in welding, and in magnesium foundries. Irritation of the eyes and nose has been reported when fluoride concentration has reached 5 mg/m<sup>3</sup> of air."

## MONITORING AND MEASUREMENT PROCEDURES

### • General

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).

### • Method

Sampling and analyses may be performed by collection of fluoride in an impinger containing sodium hydroxide, followed by dilution with a buffer, and analysis with an ion-specific electrode. An analytical method for fluoride is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 1, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00267-3).

## 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.

## PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with fluoride.

• If employees' clothing has had any possibility of being contaminated with fluoride, employees should change into uncontaminated clothing before leaving the work premises.

• Clothing contaminated with fluoride should be placed in closed containers for storage until it can be

discarded or until provision is made for the removal of fluoride from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the fluoride, the person performing the operation should be informed of fluoride's hazardous properties.

• Employees should be provided with and required to use splash-proof safety goggles where there is any possibility of sodium fluoride or liquids containing sodium fluoride contacting the eyes.

• Non-impervious clothing which becomes contaminated with fluoride should be removed promptly and not reworn until the fluoride is removed from the clothing.

## SANITATION

• Skin that becomes contaminated with fluoride should be promptly washed or showered to remove any fluoride.

• Eating and smoking should not be permitted in areas where fluoride is handled, processed, or stored.

• Employees who handle fluoride should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

## COMMON OPERATIONS AND CONTROLS

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

| Operation  | Controls   |
|--|--|
| Liberation from mining, beneficiation, packaging, and distribution of fluorspar  | Local exhaust ventilation; general dilution ventilation; personal protective equipment |
| Liberation from fluorides from phosphate rock treatment  | Local exhaust ventilation; general dilution ventilation; personal protective equipment |
| Liberation from use of fluorspars as a fluxing additive for steel production   | Local exhaust ventilation; general dilution ventilation; personal protective equipment |
| Liberation from manufacture of cryolite from phosphate rock processing; use of fluorspar and cryolite in the production of metallic aluminum by electrolysis | Local exhaust ventilation; general dilution ventilation; personal protective equipment |

| <b>Operation</b>   | <b>Controls</b>  |
|--|--|
| Use in formulations of insecticides for agricultural crops, fruits, vegetables, ornamentals, and trees   | Local exhaust ventilation; general dilution ventilation; personal protective equipment |
| Use in chemical industry as a source of fluorine compounds; use of fluorspar and cryolite in ceramics and glass industry in manufacture of fiberglass, optical glass, lenses, and pottery; use of fluorspar in manufacture of welding rods and welding fluxes; use in electroplating | Local exhaust ventilation; general dilution ventilation; personal protective equipment |
| Use in treatment of water  | Local exhaust ventilation; general dilution 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.

### • Eye Exposure

If fluoride or liquids containing fluoride get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

### • Skin Exposure

If fluoride or liquids containing fluoride get on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If fluoride or liquids containing fluoride soak through the clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. If irritation persists after washing, get medical attention.

### • Breathing

If a person breathes in large amounts of fluoride, 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.

### • Swallowing

When liquids containing fluoride have been swallowed and the person is conscious, 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.

### • 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 AND DISPOSAL PROCEDURES

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

• If fluoride is spilled or released in hazardous concentrations, the following steps should be taken:

1. Ventilate area of spill or release.
2. Collect spilled material in the most convenient and safe manner and deposit in sealed containers for reclamation or for disposal in a secured sanitary landfill. Liquid containing fluoride should be absorbed in vermiculite, dry sand, earth, or a similar material.

• Waste disposal method:

Fluoride may be disposed of in sealed containers in a secured sanitary landfill.

## REFERENCES

- American Conference of Governmental Industrial Hygienists: "Fluoride Dust," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- American Industrial Hygiene Association: "Fluoride-Bearing Dusts and Fumes (Inorganic)," *Hygienic Guide Series*, Detroit, Michigan, 1965.
- Biological Monitoring Guides: "Fluorides," *American Industrial Hygiene Association Journal*, 32:274-279, 1971.
- Committee on Biologic Effects of Atmospheric Pollutants, Division of Medical Sciences, National Research Council: *Fluorides*, Washington, D.C., 1971.
- Dinman, B. D., et al.: "Prevention of Bony Fluorosis in Aluminum Smelter Workers," *Journal of Occupational Medicine*, 18:7-25, 1976.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- Hodge, H. C., and Smith, F. A.: "Air Quality Criteria for the Effects of Fluorides on Man," *Journal of the Air Pollution Control Association*, 20:226-232, 1970.
- International Labour Office: *Encyclopedia of Occupational Health and Safety*, McGraw-Hill, New York, 1971.
- Largent, E. J.: "Rates of Elimination of Fluoride Stored in the Tissues of Man," *A.M.A. Archives of Industrial Hygiene and Occupational Medicine*, 6:37-42, 1952.

• National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . . Occupational Exposure to Inorganic Fluorides*, HEW Publication No. (NIOSH) 76-103, GPO No. 017-033-00118-9, U.S. Government Printing Office, Washington, D.C., 1975.

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

• Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.

• Stolman, A. (ed.): *Progress in Chemical Toxicology*, Academic Press, New York, 1965-1969.

• World Health Organization: *Fluorides and Human Health*, Geneva, 1970.

## RESPIRATORY PROTECTION FOR FLUORIDE DUST (AS FLUORIDE)

| <b>Condition</b>   | <b>Minimum Respiratory Protection*<br/>Required Above 2.5 mg/m<sup>3</sup></b>  |
|--|---|
| <b>Particulate Concentration</b>   |   |
| 12.5 mg/m <sup>3</sup> or less**   | A single-use dust respirator.   |
| 25 mg/m <sup>3</sup> or less**   | Any dust respirator, except single-use or quarter-mask respirator.***<br>Any supplied-air respirator.<br>Any self-contained breathing apparatus.  |
| 125 mg/m <sup>3</sup> or less  | A high efficiency particulate filter respirator with a full facepiece.***<br>Any supplied-air respirator with a full facepiece, helmet, or hood.<br>Any self-contained breathing apparatus with a full facepiece.   |
| 250 mg/m <sup>3</sup> or less  | A powered air-purifying respirator with a high efficiency particulate filter, and a full facepiece.***<br>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 250 mg/m <sup>3</sup> or entry and escape from unknown concentrations | Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.<br><br>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   | An escape gas mask with an acid gas canister.<br>Any escape self-contained breathing apparatus.   |

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

\*\*If eye irritation occurs, full-facepiece respiratory protective equipment should be used.

\*\*\*If acid gases are present, air-purifying elements providing protection against acid gases and including the indicated filters should be used.