OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR CARBONYL FLUORIDE

INTRODUCTION

This guideline summarizes pertinent information about carbonyl fluoride for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information is available.

SUBSTANCE IDENTIFICATION

- **Formula**

  CF_2O

- **Synonyms**

  Carbon difluoride oxide, carbon fluoride oxide, carbon oxyfluoride, carbonyl difluoride, difluoroformaldehyde, fluoroformyl fluoride, fluorophosgene, carbonic difluoride

- **Identifiers**

  1. CAS No.: 353-50-4
  2. RTECS No.: FG6125000
  3. DOT UN: 2417 15
  4. DOT label: Poison Gas

- **Appearance and odor**

  Carbonyl fluoride is a noncombustible, colorless, hygroscopic gas with a pungent and very irritating odor. It is shipped as a liquefied gas under its own vapor pressure.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

  1. Molecular weight: 66.01
  2. Boiling point (760 mm Hg): -83°C (-117.6°F)
  3. Specific gravity (water = 1): 1.14 at -114°C (-173°F)
  4. Vapor density: Data not available
  5. Melting point: -114°C (-173°F)
  6. Vapor pressure at 21.1°C (70°F): 42,104 mm Hg
  7. Solubility: Instantly hydrolyzed by water; decomposes in alcohol
  8. Evaporation rate: Not applicable

- **Reactivity**

  1. Conditions contributing to instability: Heat and moisture
  2. Incompatibilities: Contact with moisture causes the instantaneous hydrolysis of carbonyl fluoride to very corrosive and toxic hydrogen fluoride gas and carbon dioxide.

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3. Hazardous decomposition products: Toxic gases (such as oxides of fluorine and carbon) may be released in a fire involving carbonyl fluoride.

4. Special precautions: None

Flammability

The National Fire Protection Association has not assigned a flammability rating to carbonyl fluoride; this substance is not combustible.

1. Flash point: Not applicable

2. Autoignition temperature: Not applicable

3. Flammable limits in air: Not applicable

4. Extinguishant: Use dry chemical or carbon dioxide for small fires; water spray, fog, or regular foam for large fires.

Fires involving carbonyl fluoride should be fought upwind from the maximum distance possible. Isolate the hazard area and deny access to unnecessary personnel. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Containers of carbonyl fluoride may explode in the heat of the fire and should be removed if it is possible to do safely. If this is not possible, cool containers from the sides with water until well after the fire is out. Do not get water inside the containers. Firefighters should wear a full set of protective clothing and self-contained breathing apparatus when fighting fires involving carbonyl fluoride. Structural firefighters' protective clothing is not effective against fires involving carbonyl fluoride.

EXPOSURE LIMITS

OSHA PEL

The Occupational Safety and Health Administration (OSHA) had not promulgated a permissible exposure limit (PEL) for carbonyl fluoride [29 CFR 1910.1000, Table Z-1].

NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) of 2 ppm (5 mg/m^3) as a TWA for up to a 10-hr workday and a 40-hr workweek and 5 ppm (15 mg/m^3) as a STEL. A STEL is a 15 min exposure that should not be exceeded at any time during a workday [NIOSH 1992].

- **ACGIH TLV**

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned carbonyl fluoride a threshold limit value (TLV) of 2 ppm (5.4 mg/m^3) as a TWA for a normal 8-hr workday and a 40-hr workweek and a short-term exposure limit (STEL) of 5 ppm (13 mg/m^3) for periods not to exceed 15 min [ACGIH 1993].

- **Rationale for limits**

The ACGIH limit is based on the risk of irritation associated with exposure to carbonyl fluoride.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Exposure to carbonyl fluoride can occur through inhalation and eye or skin contact.

- **Summary of toxicology**

1. *Effects on Animals:* Carbonyl fluoride gas causes severe contact irritation or corrosion of tissues following acute exposure. In the presence of humidity or tissue fluids, it is rapidly hydrolyzed to two moles of hydrofluoric acid which is primarily responsible for the toxic effects elicited in exposed subjects. A near-lethal acute exposure, 310 ppm for 1 hr, of sacrificed mice, rats, guinea pigs, rabbits, and dogs resulted in the following histological lung changes: focal hemorrhage and edema at 24 hr; cellular repair with decreased edema at 48 hr; repair of damaged alveolar capillaries before 7 days; and a small amount of irreversible focal emphysema and mild interstitial fibrosis at the terminal 3-week sacrifice. The LC_{50}s in rats are 360 ppm for 1 hr and 90 ppm for 4 hr [NIOSH 1991]. Death resulted from respiratory or cardiac failure [NIOSH 1991; Scheel et al. 1968a]. Rats were exposed to polytetrafluoroethylene (PTFE) pyrolysis products containing hydrolyzable fluoride equal to a 50-ppm concentration of carbonyl fluoride for 1 hr/day for 5 days. Daily urinary fluoride levels reached 14 times normal on the first exposure day and continued to be markedly elevated 18 days after exposure. The animals' body weights declined by 30%, urinary glucose, protein, and ketones became

abnormal, and succinic-dehydrogenase activity declined sharply in the kidney and rose sharply in the lung. Mortality among the rats exposed repeatedly to carbonyl fluoride was high (9 of 40), indicating that fluoride continued to be liberated by hydrolysis once in the body [Scheel et al. 1968b].

2. *Effects on Humans:* Carbonyl fluoride is a severe irritant of the eyes, skin, mucous membranes, and respiratory tract in humans. Its respiratory toxicity is believed to be equivalent to that of hydrogen fluoride [ACGIH 1993]. On repeated exposure, carbonyl fluoride inhibits succinic dehydrogenase activity, indicating that sublethal exposures are cumulative and that fluoride continues to be liberated after absorption into the body [Sittig 1985].

- **Signs and symptoms of exposure**

1. *Acute exposure:* Carbonyl fluoride can cause pain, redness, and tearing of the eyes, eye or skin burns (corrosion), runny nose, coughing, pulmonary edema, and difficult breathing.

2. *Chronic exposure:* Carbonyl fluoride toxicity is similar to that caused in fluoride poisoning: respiratory distress, neurological abnormalities, gastrointestinal pain, muscular fibrillation, and skeletal fluorosis (excessive calcification of bone).

- **Emergency procedures**

> **WARNING!**
>
> **Exposed victims may die!**
> **Transport immediately to emergency medical facility**

Keep unconscious victims warm and on their sides to avoid choking if vomiting occurs. ***Immediately*** initiate the following emergency procedures, continuing them as appropriate en route to the emergency medical facility:

1. *Eye exposure:* Tissue destruction and blindness may result! If tissue is frozen, seek medical attention ***immediately***. If tissue is not frozen, ***immediately but gently*** flush the eyes with large amounts of water for at least 15 min, occasionally lifting the upper and lower eyelids. If irritation, pain, swelling, lacrimation, or photophobia develops, get medical attention as soon as possible.

2. *Skin exposure:* Severe burns and skin corrosion may result! If tissue is frozen, seek medical attention ***immediately***; do ***not*** rub the affected areas or flush them with water. If tissue is not frozen, ***immediately, continuously, and gently*** wash skin for at least 15 min. Use soap and water if skin is intact; use only water if skin is not intact.

3. *Inhalation exposure:* Move the victim to fresh air ***immediately***.

   If the victim is not breathing, clean any chemical contamination from the victim's lips and perform cardiopulmonary resuscitation (CPR); if breathing is difficult, give oxygen.

4. *Rescue:* Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the material safety data sheet required by OSHA's hazard communication standard [29 CFR 1910.1200]). All workers should be familiar with emergency procedures and the location and proper use of emergency equipment.

EXPOSURE SOURCES AND CONTROL METHODS

The following operations may involve carbonyl fluoride and may result in worker exposures to this substance:

—Use in organic synthesis

—Thermal decomposition of polytetrafluoroethylene (Teflon, Fluon, etc.)

—Proposed use as a military poison gas

The following methods are effective in controlling worker exposures to carbonyl fluoride, depending on the feasibility of implementation:

—Process enclosure

—Local exhaust ventilation

—General dilution ventilation

—Personal protective equipment

Good sources of information about control methods are as follows:

1. ACGIH [1992]. Industrial ventilation—a manual of recommended practice. 21st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burton DJ [1986]. Industrial ventilation—a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.

4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.

5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

MEDICAL MONITORING

Workers who may be exposed to chemical hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and personal protective equipment). A medical monitoring program is intended to supplement, not replace, such measures. To place workers effectively and to detect and control work-related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the term of employment, and (3) at the time of job transfer or termination.

- **Preplacement medical evaluation**

Before a worker is placed in a job with a potential for exposure to carbonyl fluoride, a licensed health care professional should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropriate for the anticipated occupational risks. These should concentrate on the function and integrity of the eyes, respiratory system, and skin. Medical monitoring for respiratory disease should be conducted using the principles and methods recommended by the American Thoracic Society [ATS 1987].

A preplacement medical evaluation is recommended to detect and assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to carbonyl fluoride at or below the prescribed exposure limit. The licensed health care professional should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. Such conditions (which should not be regarded as absolute contraindications to job placement) include a history and other findings consistent with diseases of the eyes, skin, or respiratory system.

- **Periodic medical examinations and biological monitoring**

Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federal, State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by an experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to carbonyl fluoride exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of carbonyl fluoride on the eyes, skin, or respiratory system. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference population.

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. Urinary fluoride concentration is a useful index of fluoride intake in workers; at an airborne concentration of 2.5 g/m^3 inorganic fluoride, average end-of-shift (8 hr) urinary concentrations are 4 mg fluoride per liter of urine. Some sources recommend an end-of-shift biological exposure index (BEI) of 10 mg fluoride per gram creatinine and a preshift BEI of 3 mg fluoride per gram creatinine.

- **Medical examinations recommended at the time of job transfer or termination**

The medical, environmental, and occupational history interviews, the physical examination, and selected phys-

iologic or laboratory tests that were conducted at the time of placement should be repeated at the time of job transfer or termination. Any changes in the worker's health status should be compared with those expected for a suitable reference population.

WORKPLACE MONITORING AND MEASUREMENT

A worker's exposure to airborne carbonyl fluoride is determined by using a midget fritted-glass bubbler containing 10 ml 0.1N sodium hydroxide. Samples are collected at a recommended flow rate of 2.0 liter/min until a recommended air volume of 480 liters is collected. Analysis is conducted using an ion specific electrode. This method is included in the OSHA Laboratory In-House Methods File [OSHA 1991].

PERSONAL HYGIENE

If carbonyl fluoride contacts the skin, workers should flush the affected areas immediately with plenty of water for 15 min, and then wash with soap and water.

Clothing contaminated with carbonyl fluoride should be removed immediately, and provisions should be made for safely removing this chemical from these articles.

A worker who handles carbonyl fluoride should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, using toilet facilities, or applying cosmetics.

Workers should not eat, drink, use tobacco products, or apply cosmetics in areas where carbonyl fluoride is handled, processed, or stored.

STORAGE

Carbonyl fluoride should be stored in a cool, dry, well-ventilated area in tightly sealed, pressurized containers or holding tanks that are labeled in accordance with OSHA's hazard communication standard [29 CFR 1910.1200]. All piping systems in storage areas should be equipped with leak detection equipment to provide warning of leaks. Containers of carbonyl fluoride should be protected from physical damage and should be stored separately from moisture and heat.

LEAKS

In the event of a leak involving carbonyl fluoride, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup is complete. The following steps should be undertaken following a leak:

1. Stop the leak if it is possible to do so without risk.
2. Notify safety personnel.
3. Remove all sources of heat and ignition.
4. Ventilate the area of the leak.
5. For small spills, flush area with flooding amounts of water.

SPECIAL REQUIREMENTS

U.S. Environmental Protection Agency (EPA) requirements for emergency planning, reportable quantities of hazardous releases, community right-to-know, and hazardous waste management may change over time. Users are therefore advised to determine periodically whether new information is available.

- **Emergency planning requirements**

  Carbonyl fluoride is not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (SARA) [42 USC 11022].

- **Reportable quantity requirements for hazardous releases**

  A hazardous substance release is defined by EPA as any spilling, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of contaminated containers). In the event of a release that is above the reportable quantity for that chemical, employers are required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [40 CFR 355.40] to notify the proper Federal authorities.

  The reportable quantity for carbonyl fluoride is 1,000 lb. If an amount equal to or greater than this quantity is released within a 24-hr period in a manner that will

expose persons outside the facility, employers are required to do the following:

—Notify the National Response Center ***immediately*** at (800) 424-8802 or at (202) 426-2675 in Washington, D.C. [40 CFR 302.6].

—Notify the emergency response commission of the State likely to be affected by the release [40 CFR 355.40].

—Notify the community emergency coordinator of the local emergency planning committee (or relevant local emergency response personnel) of any area likely to be affected by the release [40 CFR 355.40].

Community right-to-know requirements

Employers are not required by Section 313 of SARA [42 USC 11022] to submit a Toxic Chemical Release Inventory Form (Form R) to EPA reporting the amount of carbonyl fluoride emitted or released from their facility annually.

Hazardous waste management requirements

EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR 261.21-261.24. Carbonyl fluoride is listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA) [42 USC 6901 et seq.], and has been assigned EPA Hazardous Waste No. U033. This substance has been banned from land disposal and may be treated by incineration. Carbonyl fluoride also may be disposed of in an organometallic or organic lab pack that meets the requirements of 40 CFR 264.316 or 265.316.

Providing detailed information about the removal and disposal of specific chemicals is beyond the scope of this guideline. The U.S. Department of Transportation, EPA, and State and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (800) 424-9346 or at (202) 382-3000 in Washington, D.C. In addition, relevant State and local authorities should be contacted for information about their requirements for waste removal and disposal.

RESPIRATORY PROTECTION

- **Conditions for respirator use**

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of carbonyl fluoride exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operations such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergencies. Workers should use only respirators that have been approved by NIOSH and the Mine Safety and Health Administration (MSHA).

- **Respiratory protection program**

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's respiratory protection standard [29 CFR 1910.134]. Such a program must include respirator selection, an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, respirator fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information about the selection and use of respirators and about the medical screening of respirator users, consult the *NIOSH Respirator Decision Logic* [NIOSH 1987b] and the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987a].

PERSONAL PROTECTIVE EQUIPMENT

Protective clothing (impervious gloves, boots, aprons, and gauntlets) should be worn to prevent any skin contact with carbonyl fluoride. Chemical protective clothing should be selected on the basis of available performance data, manufacturers' recommendations, and evaluation of the clothing under actual conditions of use. No reports have been published on the resistance of various protective clothing

materials to carbonyl fluoride permeation. If permeability data are not readily available, protective clothing manufacturers should be requested to provide information on the best chemical protective clothing for workers to wear when they are exposed to carbonyl fluoride.

Safety glasses, goggles, or face shields should be worn during operations in which carbonyl fluoride might contact the eyes. Eyewash fountains and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with carbonyl fluoride. Contact lenses should not be worn if the potential exists for carbonyl fluoride exposure.

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