

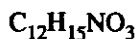
OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR CARBOFURAN

INTRODUCTION

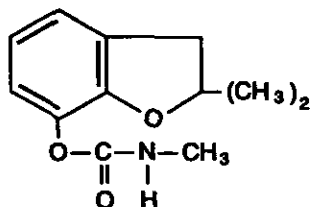
This guideline summarizes pertinent information about carbofuran for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether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



• Structure



• Synonyms

Bay 70143; Niagra 10242; Furadan; Furodan; Yaltox; Curaterr; Chinufur; 2,2-dimethyl-2,2-dihydrobenzofuranyl-7-N-methylcarbamate; methyl carbamic acid 2,3-dihydro-2,2-dimethyl-7-benzofuranyl ester

• Identifiers

1. CAS No.: 1563-66-2
2. RTECS No.: FB9450000
3. DOT UN: 2757 55
4. DOT label: Poison B

• Appearance and odor

Carbofuran is a noncombustible, odorless, colorless or white crystalline solid available commercially in the form of wettable powder, granules, or flowable paste.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 221.26
2. Boiling point (760 mm Hg): Data not available
3. Specific gravity (water = 1): 1.18 at 20°C (68°F)
4. Vapor density (air = 1 at boiling point of carbofuran): Data not available
5. Melting point: 150° to 152°C (302° to 305.6°F)
6. Vapor pressure at 33°C (91.4°F): 0.00002 mm Hg
7. Solubility: Slightly soluble in water; soluble in ace-

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tone, acetonitrile, benzene, cyclohexanone, and other organic solvents. In the conventional solvent formulations used in agriculture, carbofuran is essentially insoluble.

8. Evaporation rate: Not applicable

Reactivity

1. Conditions contributing to instability: Heat, sparks, flame, or contact with an alkaline substance
2. Incompatibilities: Fires and explosions may result from contact of carbofuran with alkaline media, acids, or strong oxidizers (such as perchlorates, peroxides, chlorates, nitrates, and permanganates).
3. Hazardous decomposition products: Toxic gases (such as oxides of nitrogen) may be released in a fire involving carbofuran.
4. Special precautions: None

Flammability

The National Fire Protection Association has not assigned a flammability rating to carbofuran; 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, water spray, or standard foam to fight fires involving carbofuran.

Fires involving carbofuran 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 carbofuran may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. Stay away from the ends of containers. Dikes should be used to contain fire-control water for later disposal. Firefighters should wear a full set of protective clothing and self-contained breathing apparatus when fighting fires involving carbofuran. Chemical protective clothing that is specifically recommended for carbofuran may provide little or no thermal protection unless so stated by the clothing manufacturer. Structural firefight-

ers' protective clothing is not effective against fires involving carbofuran.

EXPOSURE LIMITS

• OSHA PEL

The Occupational Safety and Health Administration (OSHA) has not promulgated a permissible exposure limit (PEL) for carbofuran [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 0.1 mg/m³ as a TWA for up to a 10-hr workday and a 40-hr workweek [NIOSH 1992a].

• ACGIH TLV

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned carbofuran a threshold limit value (TLV) of 0.1 mg/m³ as a TWA for a normal 8-hr workday and a 40-hr workweek [ACGIH 1993].

• Rationale for limits

The NIOSH and ACGIH limits are based on the risk of cholinesterase inhibition associated with exposure to carbofuran.

HEALTH HAZARD INFORMATION

• Routes of exposure

Exposure to carbofuran can occur through inhalation, ingestion, eye or skin contact, and percutaneous absorption.

• Summary of toxicology

1. *Effects on Animals:* In animals, carbofuran is a potent but reversible cholinesterase inhibitor. Instillation of carbofuran into the conjunctival sac caused miosis and paralysis of the ciliary muscle, both reversed by installation of atropine [Tobin 1970]. There are widely divergent dermal LD₅₀s for rabbits which range from 885 mg/kg [NIOSH 1992b] to 10,200 mg (98% carbofuran)/kg [Tobin 1970]. The rat dermal LD₅₀ is 120 mg/kg [NIOSH 1992b]. The LC₅₀ in rats is 85

mg/m³ for an unspecified period [NIOSH 1992b]. Monkeys which inhaled a 75% wettable powder (wp) dust for 6 hr at an airborne concentration of 0.86 mg/m³ showed slight but significant cholinesterase inhibition; at an exposure of 0.56 mg/m³ for the same period, no effects were seen. In addition, a monkey had sporadic tremors following a 30-min exposure to 1.3 mg/m³. Another exposed to 1.8 mg/m³ for 260 min developed only emesis [Tobin 1970]. The oral LD₅₀s for mice, rats, and dogs are 2, 5, and 19 mg/kg, respectively [NIOSH 1992b]. In experimental animals given high but non-lethal doses of carbofuran, normal cholinesterase activity returned within 6 hr [NLM 1991]. Dogs fed 50 ppm carbofuran in a chronic feeding study (length of study not specified) showed significant inhibition of plasma, erythrocyte, and brain cholinesterase levels; the no-effect levels in dogs and rats were 20 ppm (dogs) and 25 ppm (rats) [ACGIH 1991]. Administered to rats by gavage on day 18 of gestation, a dose of 2.5 mg/kg carbofuran produced cholinergic signs within 5 minutes and killed 25% of the dams within 30 minutes; a dose of 0.05 mg/kg produced nervous system effects in the dams but not in the fetuses [Hayes 1982]. No adverse reproductive or developmental effects were induced in three successive generations of rats which consumed diet containing carbofuran (10 mg/kg diet) or in dogs on a 50 mg carbofuran/kg diet for one generation [NIOSH 1992b]. When mice, rats, rabbits, and dogs consumed diets containing carbofuran (100 mg/kg), the only effect induced was decreased survival rates in rat pups [Shepard 1986]. Carbofuran is mutagenic in bacterial and mammalian test systems [NIOSH 1992b; NLM 1991].

2. *Effects on Humans:* In humans, carbofuran is a rapidly reversible cholinesterase inhibitor. No effects have been reported in workers exposed to carbofuran concentrations approaching 0.1 mg/m³ per day [NLM 1991]. Several cases of carbofuran poisoning have been reported in laboratory and pilot plant personnel and applicators. These workers developed weakness, malaise, profuse perspiration, lightheadedness, paleness, nausea, blurred vision, loss of depth perception, hypersalivation, poor coordination, and vomiting. Recovery took up to 4 hr in the absence of atropine treatment and less than 30 min when it was administered. No systemic toxicity was observed when only ocular effects were induced [Tobin 1970]. Seventy-four of 142 teenage workers who worked in a field that had been sprayed with carbofuran the previous day experienced pronounced symptoms of nervous system poisoning, including dizziness, nausea, and/or

blurred vision; however, all of these workers responded quickly and completely to therapy [Hayes 1982]. Carbofuran is mutagenic in human lymphocyte cells [NIOSH 1992b].

• **Signs and symptoms of exposure**

1. *Acute exposure:* Carbofuran can cause muscle weakness, dizziness, profuse sweating, headache, salivation, nausea, vomiting, abdominal pain, diarrhea, contracted pupils, incoordination, slurred speech, difficult breathing, chest tightness, blurred vision, muscle twitching and spasms. Convulsions may occur.
2. *Chronic exposure:* Based on effects seen in animals, long-term exposure to low levels of carbofuran is likely to cause cholinesterase inhibition.

• **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. Initiate the following emergency procedures:

1. *Eye exposure:* **Immediately and thoroughly** flush the eyes with large amounts of water for at least 15 min, occasionally lifting the upper and lower eyelids.
2. *Skin exposure:* Carbofuran can be absorbed through the skin in lethal amounts. **Immediately** remove contaminated clothing and **thoroughly** wash contaminated skin with soap and water for at least 15 min.
3. *Inhalation exposure:* Move the victim to fresh air **immediately**. Have the victim blow his or her nose or use a soft tissue to remove particulates or residues from the nostrils.

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. *Ingestion exposure:* Take the following steps if carbofuran or any material containing it is ingested:

—Have the victim rinse the contaminated mouth cavity several times with a fluid such as water.

—Have the victim drink a glass (8 oz) of fluid such as water.

—Induce vomiting by having the victim touch the back of the throat with a finger until productive vomiting ceases. Do *not* give syrup of ipecac because of possible onset of respiratory depression and seizures.

—Do *not* induce vomiting if carbofuran has been mixed with a petroleum distillate such as kerosene or diesel fuel.

—Do *not* force an unconscious or convulsing person to drink fluid or to vomit.

5. *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 carbofuran and may result in worker exposures to this substance:

—Use as an acaricide, miticide, nematocide, and insecticide

—Manufacture of carbofuran

—Formulation of carbofuran for use as a pesticide

The following methods are effective in controlling worker exposures to carbofuran, 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 carbofuran, 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 blood and on the individual's pre-exposure plasma and red blood cell cholinesterase activity levels.

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 carbofuran 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 reduced plasma or red blood cell cholinesterase activity levels.

- **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 carbofuran exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of carbofuran on plasma or red blood cell cholinesterase activity levels. 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. The measurement of red blood cell cholinesterase (RBC ChE) is a nonspecific and qualitative indicator of overexposure to organophosphorus compounds such as carbofuran. RBC ChE is an indicator both of acute and chronic overexposure. The recommended biological index for carbofuran (and other organophosphorus compounds) is an RBC ChE activity level that is at least 70% of the individual's pre-exposure baseline. The same method and laboratory should be used for pre-exposure and exposure measurements to reduce variability. Absorption of carbofuran can be confirmed by analysis of urine for its metabolite, carbofuran

phenol. However, correlations between airborne and urinary levels of carbofuran and its metabolite have not been established.

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

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time of placement should be repeated at the time of job transfer or termination to determine the worker's medical status at the end of his or her employment. 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 carbofuran is determined by using an OSHA Versatile Sampler (OVS-2) with a 13-mm XAD-2 tube (270/140-mg sections, 20/60 mesh). Samples are collected at a recommended flow rate of 1.0 liter/min until a recommended air volume of 480 liters is collected. The sample is then treated with acetonitrile to extract the carbofuran. Analysis is conducted by high performance liquid chromatography using an ultraviolet detector. This method is included in the OSHA Laboratory In-House Methods File [OSHA 1989].

PERSONAL HYGIENE

If carbofuran contacts the skin, workers should immediately wash the affected areas with soap and water.

Clothing contaminated with carbofuran should be removed immediately, and provisions should be made for safely removing this chemical from these articles. Persons laundering the clothes should be informed of the hazardous properties of carbofuran.

A worker who handles carbofuran 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 carbofuran or a solution containing carbofuran is handled, processed, or stored.

STORAGE

Carbofuran should be stored in a cool, dry, continuously-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's hazard communication standard [29 CFR 1910.1200]. Containers of carbofuran should be protected from physical damage and should be stored separately from acids, strong oxidizers (such as perchlorates, peroxides, and nitrates), heat, sparks, and open flame. Because containers that formerly contained carbofuran may still hold product residues, they should be handled appropriately.

SPILLS AND LEAKS

In the event of a spill or leak involving carbofuran, 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 spill or leak:

1. Do not touch the spilled material; stop the leak if it is possible to do so without risk.
2. Notify safety personnel.
3. Ventilate the area of the spill or leak.
4. For small dry spills, use a clean shovel and gently place the material into a clean, dry container creating as little dust as possible; cover and remove the container from the spill area.
5. For liquid spills, absorb with sand or other noncombustible absorbent material and place into closed containers for later disposal.

SPECIAL REQUIREMENTS

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

Employers owning or operating a facility at which there are 10,000 lb or more of carbofuran must comply with EPA's emergency planning requirements. (If carbofuran

is in the form of a finely divided powder or is handled in solution or in molten form, the employer must comply with these requirements if 10 lb or more of carbofuran are present at the facility.)

• 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, State, and local authorities.

The reportable quantity for carbofuran is 10 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 the Superfund Amendments and Reauthorization Act (SARA) [42 USC 11022] to submit a Toxic Chemical Release Inventory Form (Form R) to EPA reporting the amount of carbofuran 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. Although carbofuran is not specifically listed as

a hazardous waste under the Resource Conservation and Recovery Act (RCRA) [40 USC 6901 et seq.], EPA requires employers to treat waste as hazardous if it exhibits any of the characteristics discussed above.

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 carbofuran 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 informa-

tion 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 gloves and clothing should be worn to prevent any skin contact with carbofuran. 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 carbofuran 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 carbofuran.

If carbofuran is dissolved in an organic solvent, the permeation properties of both the solvent and the mixture must be considered when selecting personal protective equipment and clothing.

Safety glasses, goggles, or face shields should be worn during operations in which carbofuran might contact the eyes (e.g., through dust particles or splashes of carbofuran-containing solutions). Eyewash fountains and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with carbofuran. Contact lenses should not be worn if the potential exists for carbofuran exposure.

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