

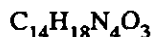
# OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR BENOMYL

## INTRODUCTION

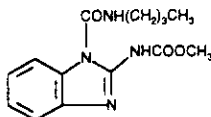
This guideline summarizes pertinent information about benomyl for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health programs. Recommendations may be superseded by new developments; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information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

1-(Butylcarbamoyl)-2-benzimidazolecarbamate; methyl ester; 1-(butylcarbamoyl)-2-benzimidazole-methylcarbamate; 1-(n-butylcarbamoyl)-2-(methoxy-carboxamido)-benzimidazole; carbamic acid; methyl 1-(butylcarbamoyl)-2-benzimidazole ester; Benlate; Arilate; BBC; Benlate 50; Benomyl 50W; BNM; Fundasol; Fungicide 1991; MBC; Tersan 1991

### • Identifiers

1. CAS No.: 17804-35-2
2. RTECS No.: DD6475000
3. DOT UN: 2757 55 (carbamate pesticide, solid, not otherwise specified)
4. DOT label: Poison or St. Andrew's Cross (depending on quantity shipped)

### • Appearance and odor

Benomyl is a noncombustible, white, crystalline solid that decomposes without melting. It has a faint, acrid odor.

## CHEMICAL AND PHYSICAL PROPERTIES

### • Physical data

1. Molecular weight: 290.32
2. Boiling point (760 mm Hg): Not applicable
3. Specific gravity: Data not available
4. Vapor density: Data not available
5. Melting point: Decomposes without melting above 300°C (572°F)
6. Vapor pressure at 20°C (68°F): Less than 0.1 mm Hg
7. Solubility: Very slightly soluble in water; soluble in ethanol, heptane, xylene, acetone, dimethylformamide, and chloroform
8. Evaporation rate: Not applicable

### • Reactivity

1. Conditions contributing to instability: Heat, water, strong acids, and strong alkalis can cause benomyl to decompose.
2. Incompatibilities: None reported
3. Hazardous decomposition products: Toxic gases (such as oxides of nitrogen) may be released in a fire involving benomyl.
4. Special precautions: None reported

### • Flammability

The National Fire Protection Association has not assigned a fire hazard rating to benomyl; this substance is not combustible.

1. Flash point: Not applicable

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Public Health Service Centers for Disease Control  
National Institute for Occupational Safety and Health  
Division of Standards Development and Technology Transfer

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

2. Autoignition temperature: Not applicable
3. Flammable limits in air: Not applicable
4. Extinguishant: Use an extinguishant that is suitable for the materials involved in the surrounding fire.

Firefighters should wear a full set of protective clothing (including a self-contained breathing apparatus) when fighting fires involving benomyl.

## EXPOSURE LIMITS

### • OSHA PEL

The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for benomyl is 10 mg/m<sup>3</sup> of air (total dust) and 5 mg/m<sup>3</sup> (respirable fraction) as an 8-hr time-weighted average (TWA) concentration [29 CFR 1910.1000, Table Z-1-A].

### • NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has no recommended exposure limit (REL) for benomyl [NIOSH 1992].

### • ACGIH TLV<sup>®</sup>

The American Conference of Governmental Industrial Hygienists (ACGIH) has assigned benomyl a threshold limit value (TLV) of 10 mg/m<sup>3</sup> (0.84 ppm) as a TWA for a normal 8-hr workday and a 40-hr workweek [ACGIH 1991b].

### • Rationale for limits

The OSHA limit is based on the risk of physical irritation, erythema, and potential reproductive effects associated with exposure to benomyl; the ACGIH limit is based on the low toxicity of this substance.

## HEALTH HAZARD INFORMATION

### • Routes of exposure

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

### • Summary of toxicology

1. *Effects on Animals:* Benomyl is a skin sensitizer, reproductive toxin, and teratogen in animals. When instilled into the eyes of rabbits, dry benomyl powder (50%) or 0.1 ml of a 10% benomyl solution produced only temporary, mild irritation of the conjunctiva [ACGIH 1991a]. When applied to the intact, shaved skin of guinea pigs, a benomyl concentration of 25% in a 50% wettable powder produced reddened skin in 1 of 10 animals; lower concentrations of benomyl did not cause skin irritation [ACGIH 1991a]. Benomyl caused mild to moderate skin sensitization in guinea pigs injected intradermally with benomyl and

then challenged by topical application [Clayton and Clayton 1981]. The dermal LD<sub>50</sub> in rabbits is greater than 10 g/kg [ACGIH 1991a]. The LC<sub>50</sub> in rats is greater than 2,000 mg/m<sup>3</sup> for 4 hr. The oral LD<sub>50</sub> in rats is 10 g/kg [NIOSH 1991]. Rats exposed to 100 mg/m<sup>3</sup> for 4 hr/day, 5 days/week for 3 weeks developed neither clinical or histopathological effects [NLM 1991]. Rats exposed to technical-grade benomyl at 10, 50, or 200 mg/m<sup>3</sup> for 6 hr/day, 5 days/week for 14 weeks had suppressed food consumptions and body weight gains at the highest level. Only the 50- and 200-mg/m<sup>3</sup> exposures induced any effect (a degeneration of the olfactory epithelium) after 45 days. Oral administration of benomyl (2,500 mg/kg in the diet) to rats for 90 days did not cause toxicity, but rats and dogs fed benomyl for 2 years exhibited a low order of toxicity (undefined) [NLM 1991].

A number of studies [Barnes et al. 1983; Carter et al. 1984; Ellis et al. 1987] have demonstrated benomyl's reproductive and teratogenic effects. Adult rats fed benomyl for 70 days showed significant depressions in sperm count and testicular weight and had lowered fertility indexes [Barnes et al. 1983]. Similar effects were elicited in rats given benomyl during or after puberty [Carter et al. 1984]. Rats intubated with benomyl doses ranging from 125 to 500 mg/kg per day during the first 20 days of pregnancy produced offspring with dose-related increases in the rates of skull and central nervous system anomalies [NLM 1991]. In addition, pregnant mice administered 1,100 mg/kg benomyl on days 7 to 17 of pregnancy had offspring with similar abnormalities [NIOSH 1991]. In another study, the offspring of rats given 31.2, 62.5, or 125 mg/kg by gavage on days 7 to 21 of gestation showed a dose-dependent increase in the incidence of craniocerebral and systemic malformations; an increase in fetal resorptions and late fetal deaths also occurred in the offspring of animals in the high-dose group [Ellis et al. 1987]. Although benomyl is mutagenic in bacterial test systems [NIOSH 1991], it did not induce cancer in either rats or dogs fed the compounds for two years [NLM 1991].

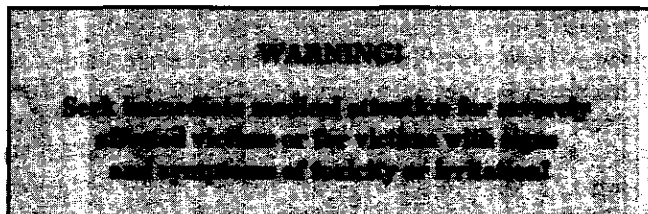
2. *Effects on Humans:* Benomyl is an irritant and skin sensitizer in humans. A recent U.S. study showed that two migrant workers in a group of farm workers with dermatitis had positive responses to 0.1% benomyl solutions in patch tests, indicating that they had become sensitized to this substance [Schuman and Dobson 1985]. A field study in Japanese farmers showed that 20% of women farmers had positive patch tests to benomyl as well as cross-sensitivities to other pesticides [Matsushita and Aoyama 1981]. Irritation, erythema, salivation, sweating, lassitude, reproductive effects, muscular incoordination, nausea, vomiting, abdominal cramps, angina pectoris, central nervous system depression, and cholinesterase inhibition have been reported [NLM 1991]. Benomyl is mutagenic in human in vitro test systems [NIOSH 1991].

### • Signs and symptoms of exposure

1. *Acute exposure:* Acute exposure to benomyl dust can cause irritation, erythema, salivation, sweating, lassitude, reproductive effects, muscular incoordination, nausea, vomiting, abdominal cramps, angina pectoris, central nervous system depression, and cholinesterase inhibition.

2. *Chronic exposure:* Chronic exposure to benomyl may cause skin sensitization with irritation, redness, and cholinesterase inhibition.

### • Emergency procedures



Keep unconscious victims warm and on their sides to avoid choking if vomiting occurs. Initiate the following emergency procedures:

1. *Eye exposure:* Tissue irritation may result from exposure to particulates or concentrated solutions, vapors, mists, or aerosols of benomyl. **Immediately and thoroughly** flush the eyes with large amounts of water, occasionally lifting the upper and lower eyelids.

2. *Skin exposure:* Skin irritation may result. **Immediately** remove contaminated clothing and **thoroughly** wash contaminated skin with soap and water.

3. *Inhalation exposure:* If particulates or vapors, mists, or aerosols of benomyl are inhaled, 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. *Ingestion exposure:* Take the following steps if benomyl 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 giving syrup of ipecac as directed on the package. If ipecac is unavailable, have the victim touch the back of the throat with a finger until productive vomiting ceases.

—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 proce-

dures (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 benomyl and may result in worker exposures to this substance:

—Manufacture and formulation of pesticides containing benomyl

—Use of benomyl as a systemic fungicide and ascaricide

—Use of benomyl in veterinary medicine as an anthelmintic

—Use of benomyl as an oxidizer in sewage treatment

The following methods are effective in controlling worker exposures to benomyl, 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, placement of workers in jobs that do not jeopardize their safety or health, 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 benomyl, 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 skin.

A preplacement medical evaluation is recommended to assess an individual's suitability for employment at a specific job and to detect and assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to benomyl 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 of skin allergies or other diseases of the skin. On the basis of effects seen in animals, men and women who plan to have children should be advised that they may be at increased risk of having a child with birth defects, and men should be advised that they may be at increased risk of experiencing adverse reproductive effects.

- **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 benomyl exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of benomyl on the skin and the male reproductive system. Men and women who plan to have children should again be advised that they may be at in-

creased risk of having a child with birth defects. 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. No biological monitoring test acceptable for routine use has yet been developed for benomyl.

- **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 job 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 benomyl is determined by using an OSHA Versatile Sampler (OVS-2) with a 13-mm XAD-2 tube (270/140-mg sections, 20/50 mesh). Samples are collected at a maximum flow rate of 1 liter/min until a maximum air volume of 480 liters is collected. Analysis is conducted by high-performance liquid chromatography. This method is described in the OSHA Computerized Information System [OSHA 1989].

## **PERSONAL HYGIENE**

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

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

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

Workers should not eat, drink, or use tobacco products in areas where benomyl or a solution containing benomyl is handled, processed, or stored.

## **STORAGE**

Benomyl should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's hazard communication standard [29 CFR 1910.1200]. Containers of benomyl should be protected

from physical damage and should be stored separately from strong acids, strong alkalis, heat, sparks, and open flame. Because containers that formerly contained benomyl may still hold product residues, they should be handled appropriately.

## SPILLS AND LEAKS

In the event of a spill or leak involving benomyl, 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.
2. Notify safety personnel.
3. Ventilate the area of the spill or leak.
4. For dry spills, use a vacuum or a wet method to reduce dust dispersion and place the material into a clean, dry container; cover and remove the container from the spill area.
5. Absorb liquid spills with sand or other noncombustible absorbent material and place the material in a covered container for later disposal.

## 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

Benomyl 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

Employers are not required by the emergency release notification provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [40 CFR 355.40] to notify the National Response Center of an accidental release of benomyl; there is no reportable quantity for this substance.

### • Community right-to-know requirements

Employers are not required by Section 313 SARA to submit a Toxic Chemical Release Inventory Form (Form R) to EPA reporting the amount of benomyl 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 benomyl 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 benomyl 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, 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 on the selection and use of respirators and on 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 skin contact with benomyl. 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 benomyl 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 benomyl.

If benomyl is dissolved in water or 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 benomyl might contact the eyes (e.g., through dust particles or splashes of solution). Eyewash fountains and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with benomyl. Contact lenses should not be worn if the potential exists for benomyl exposure.

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