

Occupational Health Guideline for Dimethyl Formamide

INTRODUCTION

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

SUBSTANCE IDENTIFICATION

- Formula: $\text{HCON}(\text{CH}_2)_2$
- Synonyms: N,N-dimethyl formamide; DMF
- Appearance and odor: Colorless liquid with a faint, ammonia-like odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for dimethyl formamide is 10 parts of dimethyl formamide per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 30 milligrams of dimethyl formamide per cubic meter of air (mg/m^3).

HEALTH HAZARD INFORMATION

• Routes of exposure

Dimethyl formamide can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.

• Effects of overexposure

1. Short-term Exposure: Inhalation of dimethyl formamide or skin contact with dimethyl formamide may cause abdominal distress, colicky abdominal pain, loss of appetite, nausea, vomiting, constipation, diarrhea, facial flushing (especially after drinking alcohol), liver injury, agitation, and increased blood pressure. Skin contact may cause skin irritation.

2. Long-term Exposure: Repeated or prolonged skin contact with dimethyl formamide may cause a 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 dimethyl formamide.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to dimethyl formamide 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 liver, kidneys, and cardiovascular system should be stressed. The skin should be examined for evidence of chronic disorders.

—Liver function tests: Since liver damage has been observed in humans exposed to dimethyl formamide, a profile of liver function should be obtained by using a medically acceptable array of biochemical tests.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

• Summary of toxicology

Dimethyl formamide vapor is toxic to the liver. Repeated exposure of rats to concentrations of 100 to 450 ppm for 4 months resulted in necrosis of the liver and mild kidney damage. Animal studies have shown toxic effects at high levels on multiple organ systems. Thirteen workers exposed to concentrations below 20 ppm and occasionally to higher levels for up to 32 weeks complained of nausea, vomiting, and colic; some cases of hepatomegaly were detected. A worker who was splashed with the liquid over 20% of his body surface initially suffered only dermal irritation and hyperemia; abdominal pain began 62 hours after the exposure and became progressively more severe, with vomiting; the blood pressure was elevated to 190/100; the effects gradually subsided and were entirely abated by the 7th day after the exposure. Some workers have noted flushing of the face after inhalation of the vapor, especially with coincident ingestion of alcoholic beverages.

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

ages. Effects resemble those of porphyria. Prolonged or repeated skin contact with the liquid may cause dermatitis as a result of a defatting action.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 73.1
2. Boiling point (760 mm Hg): 153 C (307 F)
3. Specific gravity (water = 1): 0.94
4. Vapor density (air = 1 at boiling point of dimethyl formamide): 2.5
5. Melting point: -61 C (-78 F)
6. Vapor pressure at 20 C (68 F): 2.7 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Miscible in all proportions
8. Evaporation rate (butyl acetate = 1): 0.17

• Reactivity

1. Conditions contributing to instability: Temperatures above 350 C (662 F) may cause decomposition and development of pressure in closed containers.

2. Incompatibilities: Contact with carbon tetrachloride and other halogenated compounds, particularly when in contact with iron, or contact with strong oxidizers may cause fires and explosions. Dimethyl formamide may react vigorously with alkylaluminums when the latter are used as polymerization catalysts.

3. Hazardous decomposition products: Toxic gases and vapors (such as dimethylamine and carbon monoxide) may be released in a fire involving dimethyl formamide.

4. Special precautions: Dimethyl formamide will attack some forms of plastics, rubber, and coatings.

• Flammability

1. Flash point: 58 C (136 F) (closed cup)
2. Autoignition temperature: 445 C (833 F)
3. Flammable limits in air, % by volume: Lower: 2.2; Upper: 15.2 (at 100 C (212 F))
4. Extinguishant: Alcohol foam, dry chemical, carbon dioxide. Do not use halogenated extinguishing media.

• Warning properties

1. Odor Threshold: According to the Department of Transportation's *Hazardous Chemical Data*, the odor threshold of dimethyl formamide is 100 ppm.

2. Eye Irritation Level: According to Deichmann and Gerarde, dimethyl formamide "is highly irritating to skin, eyes, and mucous membranes." No quantitative information is available concerning the threshold levels of irritation.

3. Evaluation of Warning Properties: Since the odor threshold of dimethyl formamide is 10 times higher than the permissible exposure limit, and since no other quantitative information is available relating to warning properties to air concentrations, this substance is treated as a material with poor warning properties.

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 dimethyl formamide vapors using a silica gel tube, followed by desorption with methanol, and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure dimethyl formamide may be used. An analytical method for dimethyl formamide is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 5, 1979, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00349-1).

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 liquid dimethyl formamide.

• Non-impervious clothing which becomes contaminated with dimethyl formamide should be removed

promptly and not reworn until the dimethyl formamide is removed from the clothing.

- Employees should be provided with and required to use splash-proof safety goggles where liquid dimethyl formamide may contact the eyes.

SANITATION

- Skin that becomes contaminated with dimethyl formamide should be promptly washed or showered to remove any dimethyl formamide.

- Employees who handle liquid dimethyl formamide should wash their hands thoroughly before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

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

Operation	Controls
Use as resin and polymer solvent as spinning solvent for acrylic fibers; booster solvent in coating, printing, and adhesive formulations	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as a chemical intermediate, catalyst and reaction medium in chemical manufacturing industry	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as a selective absorption and extraction solvent for recovery, purification absorption, separation and desulfurization of non-paraffinics from paraffin hydrocarbons	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in manufacture of paint stripper component for removal of vinyl films, epoxy coatings, and varnish finishes	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment

Operation

Use in pigment and dye industry to improve dyeing properties; use as solvent of dyes and pigments for use with textiles, wood, leather, films, paper, and plastics; use as a crystallization solvent in pharmaceutical industry; use as a solvent for carbonaceous deposit cleaning

Use in miscellaneous applications for high-voltage capacitors, oil sludge dispersing agent, antistall gasoline additive, quench for tinned parts and wood pulping

Controls

Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment

Process enclosure; 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 liquid dimethyl formamide gets 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 liquid dimethyl formamide gets on the skin, promptly flush the contaminated skin with water. If liquid dimethyl formamide soaks through the clothing, remove the clothing promptly and flush the skin with water. Get medical attention promptly.

• Breathing

If a person breathes in large amounts of dimethyl formamide, 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 liquid dimethyl formamide has 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 some-

one 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, LEAK, AND DISPOSAL PROCEDURES

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

- If liquid dimethyl formamide is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. For small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be reclaimed or collected and atomized in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device. Dimethyl formamide should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion. Sewers designed to preclude the formation of explosive concentrations of dimethyl formamide vapors are permitted.

- Waste disposal methods:

Dimethyl formamide may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.
2. By atomizing in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Dimethylformamide," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

- American Industrial Hygiene Association: "Dimethylformamide," *Hygienic Guide Series*, Detroit, Michigan, 1957.
- Baskin, A. D. (ed.): *Handling Guide for Potentially Hazardous Commodities*, Railway Systems and Management Association, Chicago, 1972.
- Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.
- Clayton, J. W., Jr., et al.: "The Inhalation Toxicity of Dimethylformamide (DMF)," *American Industrial Hygiene Association Journal*, 24:144-154, 1963.
- Deichmann, W. B., and Gerarde, H. W.: *Toxicology of Drugs and Chemicals*, Academic Press, New York, 1969.
- Department of Transportation: *CHRIS Hazardous Chemical Data*, CG-446-2, U.S. Government Printing Office, Washington, D.C., January 1974.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- Hamilton, A., and Hardy, H.: *Industrial Toxicology* (3rd ed.), Publishing Sciences Group, Acton, Massachusetts, 1974.
- *Handbook of Organic Industrial Solvents*, Technical Guide No. 6 (4th ed.); American Mutual Insurance Alliance, Chicago, 1972.
- International Labour Office: *Encyclopedia of Occupational Health and Safety*, McGraw-Hill, New York, 1971.
- Massmann, W.: "Toxicological Investigations on Dimethylformamide," *British Journal of Industrial Medicine*, 13:51-54, 1956.
- Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.
- Potter, H. P.: "Dimethylformamide-Induced Abdominal Pain and Liver Injury," *Archives of Environmental Health*, 27:340-341, 1973.
- Spector, W. S. (Vols. I, II), Negherbon, W. O. (Vol. III), Grebe, R. M. (Vol. IV), and Dittmer, D. S. (Vol. V) (eds.): *Handbook of Toxicology*, Saunders, Philadelphia, 1956-1959.
- Stauden, A. (exec. ed.): *Kirk-Othmer Encyclopedia of Chemical Technology* (2nd ed.), Interscience, New York, 1972.
- Stecher, P. G. (ed.): *The Merck Index* (8th ed.), Merck Co., Inc., Rahway, New Jersey, 1968.

RESPIRATORY PROTECTION FOR DIMETHYL FORMAMIDE

Condition	Minimum Respiratory Protection* Required Above 10 ppm
Vapor Concentration	
100 ppm or less	Any supplied-air respirator.** Any self-contained breathing apparatus.**
500 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
3500 ppm or less	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 3500 ppm*** or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors. 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.

***Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of dimethyl formamide; however, this equipment should be selected, used, and maintained under the immediate supervision of trained personnel. Where supplied-air suits are used above a concentration of 3500 ppm, an auxiliary self-contained breathing apparatus operated in positive pressure mode should also be worn.

