

Occupational Health Guideline for Propylene Oxide *

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: $\text{CH}_2\text{CHOCH}_2$
- Synonyms: 1,2-Epoxypropane; propene oxide; methyloxirane
- Appearance and odor: Colorless liquid with an ether-like odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for propylene oxide is 100 parts of propylene oxide per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 240 milligrams of propylene oxide per cubic meter of air (mg/m^3). The American Conference of Governmental Industrial Hygienists has issued a Notice of Intended Changes of its recommended Threshold Limit Value for propylene oxide from 100 ppm to 20 ppm.

HEALTH HAZARD INFORMATION

• Routes of exposure

Propylene oxide can affect the body if it is inhaled, is swallowed, or comes in contact with the eyes or skin.

• Effects of overexposure

Overexposure to propylene oxide may cause irritation of the eyes, nose, throat, and lungs. Contact with propylene oxide liquid may cause skin or eye irritation or burns.

• 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 propylene oxide.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to propylene oxide at potentially hazardous levels:

1. Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from propylene oxide exposure.

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

—Liver disease: Although propylene oxide is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Kidney disease: Although propylene oxide is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of propylene oxide might cause exacerbation of symptoms due to its irritant properties.

2. Periodic Medical Examination: Any employee developing the above-listed conditions should be referred for further medical examination.

• Summary of toxicology

Propylene oxide is a severe irritant and a mild depressant of the central nervous system. Excessive exposure of animals to vapors caused irritation of the eyes, upper respiratory tract, and lungs, as well as central nervous system effects characterized by ataxia, incoordination, and general depression. The LC50 for single exposures of rats was 3600 ppm, while 400 to 500 ppm was lethal

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.

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Public Health Service Centers for Disease Control
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to some rats on repeated daily exposures. The predominant effect was lung irritation and infection. All animals tolerated repeated exposures of 100 ppm without effects. Reported adverse effects on man have been confined to injury to the eyes, and skin. The vapor is irritating to the eyes and the liquid causes corneal burns. When confined to the skin, as from wearing contaminated clothing or shoes, the material and water solutions as dilute as 10% are likely to cause irritation, blistering, and even burns upon single, short exposures. Some evidence indicates that solutions more dilute than 10% may be more irritating than the undiluted propylene oxide. No chronic systemic effects have been reported in humans.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 58
2. Boiling point (760 mm Hg): 34 C (94 F)
3. Specific gravity (water = 1): 0.83
4. Vapor density (air = 1 at boiling point of propylene oxide): 2.0
5. Melting point: -112 C (-170 F)
6. Vapor pressure at 20 C (68 F): 442 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 40.5
8. Evaporation rate (butyl acetate = 1): 33.7

• Reactivity

1. Conditions contributing to instability: Heat; contact with acids and caustics
2. Incompatibilities: Anhydrous metal chlorides such as iron or aluminum chloride, strong acids, caustics, and peroxides cause polymerization with liberation of heat.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving propylene oxide.
4. Special precautions: Propylene oxide will attack some forms of plastics, rubber, and coatings. No acetylide-forming metals such as copper or copper alloys should be in contact with propylene oxide.

• Flammability

1. Flash point: -37 C (-35 F) (closed cup)
2. Autoignition temperature: 748 C (1378 F)
3. Flammable limits in air, % by volume: Lower: 2.1; Upper: 37.0
4. Extinguishant: Dry chemical, alcohol foam, carbon dioxide

• Warning properties

1. Odor Threshold: Patty states that "the median detectable concentration of propylene oxide vapors is reported to be 200 ppm with 95% confidence limits of 114 to 353 ppm. The odor is described as sweet, alcoholic, and like natural gas, ether, or benzene."
 2. Eye Irritation Level: Grant reports that "exposure of monkeys and rabbits to 457 ppm of vapor in air for 7 hours daily had no adverse effect, but in rats and guinea pigs it irritated the eyes and induced lung edema."
- The AIHA *Hygienic Guide*, Patty, the *Documentation*

of TLV's, and several other sources all note that propylene oxide causes eye irritation. However, no quantitative information is available, concerning the threshold of eye irritation.

3. Evaluation of Warning Properties: Patty states that "neither odor nor irritation can be relied upon to warn of the presence of vapor concentrations not suitable for prolonged and repeated exposure. Odor and/or irritation will warn of the presence of acutely dangerous concentrations." Since it appears that Patty considers any vapor concentrations above 100 ppm (the ACGIH threshold limit for 1961) "not suitable for prolonged and repeated exposure," propylene oxide is considered to have adequate warning properties for the purposes of this guideline. The median of the detectable odor concentrations (200 ppm) is only twice the permissible exposure limit. The chronic exposure data given in the *Documentation of TLV's* quoted below do not indicate that 200 ppm causes any toxic effects.

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 propylene oxide vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure propylene oxide may be used. An analytical method for propylene oxide is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 2, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00260-6).

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 any possibility of skin contact with liquid propylene oxide.
- Clothing wet with liquid propylene oxide should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of propylene oxide from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the propylene oxide, the person performing the operation should be informed of propylene oxide's hazardous properties.
- Where there is any possibility of exposure of an employee's body to liquid propylene oxide, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.
- Non-impervious clothing which becomes contaminated with liquid propylene oxide or any clothing which becomes wet with liquid propylene oxide should be removed immediately and such clothing should not be reworn until the propylene oxide is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where liquid propylene oxide may contact the eyes.

SANITATION

- Skin that becomes contaminated with liquid propylene oxide should be immediately washed or showered to remove any propylene oxide.

COMMON OPERATIONS AND CONTROLS

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

Operation

Use in manufacture of polypropylene glycol and polyether polyols in production of polyurethane foam; manufacture of propylene glycol for use as a solvent, emulsifier, and mold inhibitor; manufacture of dipropylene glycol for use as a solvent, ink formulations, and glycol esters for solvents, oil additives, and hydraulic brake fluids

Use as a chemical intermediate in the production of lubricants, surfactants, and miscellaneous chemicals for pharmaceutical, petroleum, textile, rubber, and soap industries

Use as a low-boiling solvent for cellulose derivatives, hydrocarbons, commercial gums, and various resins

Use as a fumigant (moth-proofing agent), herbicide, germicide, insecticide, and stabilizer of vinyl resin lacquers and discoloration preventer of hydrocarbons

Use as a food preservative as a fungicide and fumigant

Liberation during hydroxypropylating of wheat flour in order to modify it to mix readily with water

Controls

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

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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 propylene oxide gets into the eyes, wash eyes immediately with large amounts of water for 15 minutes, lifting the lower and upper lids occasionally. Get medical attention as soon as possible. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If propylene oxide gets on the skin, immediately wash the contaminated skin with water if propylene oxide has not already evaporated. If propylene oxide soaks through the clothing, remove the clothing immediately and flush the skin with water. If there is skin irritation, get medical attention.

• Breathing

If a person breathes in large amounts of propylene oxide, 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

If propylene oxide has been swallowed, do not induce vomiting. 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, 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 propylene oxide 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 may be collected, dissolved in alcohol of greater molecular weight than butyl alcohol, and atomized in a suitable combustion chamber. Propylene oxide should

not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion.

• Waste disposal method:

Propylene oxide may be disposed of by dissolving in alcohol of greater molecular weight than butyl alcohol and atomizing in a suitable combustion chamber.

REFERENCES

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

• American Industrial Hygiene Association: "Propylene Oxide," *Hygienic Guide Series*, Detroit, Michigan, 1959.

• Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.

• Dow Chemical Company: "Alkylene Oxides from Dow," *Product Bulletin*, Midland, Michigan, 1963.

• Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.

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

• Union Carbide Corporation, Industrial Medicine and Toxicology Department: *Toxicology Studies - Propylene Oxide*, New York, 1971.

* SPECIAL NOTE

The International Agency for Research on Cancer (IARC) has evaluated the data on this chemical and has concluded that it causes cancer. See *IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man*, Volume 11, 1976.

RESPIRATORY PROTECTION FOR PROPYLENE OXIDE

Condition	Minimum Respiratory Protection* Required Above 100 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s). A gas mask with a chin-style or a front- or back-mounted organic vapor canister.
2000 ppm or less	Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 2000 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.

**Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of propylene oxide; 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 2000 ppm, an auxiliary self-contained breathing apparatus operated in positive pressure mode should also be worn.