

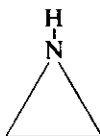
OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR ETHYLENEIMINE POTENTIAL HUMAN CARCINOGEN

INTRODUCTION

This guideline summarizes pertinent information about ethyleneimine for workers, employers, and 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 Recommendations may be superseded by new developments in these fields; therefore, readers are advised to regard these recommendations as general guidelines.

SUBSTANCE IDENTIFICATION

- **Formula:** C₂H₃N
- **Structure:**



- **Synonyms:** Aminoethylene, azirane, dihydroazirane, dihydro-1h-azirine, dimethyleneimine, dimethylenimine
- **Identifiers:** CAS 151-56-4; RTECS KX5075000; DOT 1185, label required: "Flammable Liquid, Poison"
- **Appearance and odor:** Colorless volatile liquid with an intense odor like ammonia

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**
 1. Molecular weight: 43.08
 2. Boiling point (at 760 mmHg): 56°C (132°F)
 3. Specific gravity (water = 1): 0.8321
 4. Vapor density (air = 1 at boiling point of ethyleneimine): 1.5
 5. Melting point: -59°C (-74°F)
 6. Vapor pressure at 20°C (68°F): 160 mmHg
 7. Soluble in water
- **Reactivity**
 1. Incompatibilities: Contact with silver, aluminum, or acid may cause explosive polymerization.
 2. Hazardous decomposition products: Toxic vapors and gases (e.g., carbon monoxide and oxides of nitrogen) may be released in a fire involving ethyleneimine.

- **Flammability**

1. Flash point: -11.1°C (12°F) (closed cup)
2. Autoignition temperature: 320°C (608°F)
3. Flammable limits in air, % by volume: Lower, 3.6; Upper, 46
4. Extinguishant: Dry chemical, alcohol foam, or carbon dioxide
5. Class IB Flammable Liquid (29 CFR 1910.106), Flammability Rating 3 (NFPA)

- **Warning properties**

1. Odor threshold: 2 ppm
2. Eye irritation levels: 100 ppm
3. Evaluation of warning properties for respirator selection: Warning properties are not considered in recommending respirators for use with carcinogens.

EXPOSURE LIMITS

The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for ethyleneimine is 0.5 ppm [1.0 milligram of ethyleneimine per cubic meter of air (mg/m³)] (Skin) as a time-weighted average (TWA) concentration over an 8-hour workshift. The notation "Skin" refers to the potential contribution to overall exposure by the cutaneous route including the mucous membranes and eyes. The OSHA standard requires implementation of stringent controls wherever ethyleneimine or solid or liquid mixtures containing at least 0.1% by weight or volume of ethyleneimine are manufactured, processed, repackaged, released, handled, or stored (see "General Control Procedures"). Details of this standard can be found in the Code of Federal Regulations, 29 CFR 1910.1012, Ethyleneimine. The National Institute for Occupational Safety and Health (NIOSH) concurs with the OSHA standard. The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV[®]) is 0.5 ppm (1.0 mg/m³) (Skin) as a TWA for a normal 8-hour workday and a 40-hour workweek.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Ethyleneimine may cause adverse health effects following exposure via inhalation, ingestion, or dermal contact.

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

• Summary of toxicology

1. *Effects on animals:* In rabbits and cats, acute instillation of ethyleneimine in the eyes caused damage, blindness, and death; oral administration of ethyleneimine to rats caused decreased white blood cell counts and tissue degeneration of the liver, kidneys, and heart. Subchronic subcutaneous injection of ethyleneimine in rats produced injection-site skin cancer. Chronic oral administration of ethyleneimine to mice produced cancers of the liver and lungs.

2. *Effects on humans:* Acute inhalation or dermal exposure of laboratory workers has caused central nervous system (CNS) effects, excess fluid in the lungs, damage to the liver and kidneys, and in some cases, death.

• Signs and symptoms of exposure

Short-term exposure (acute): Exposure to ethyleneimine can cause delayed onset headache, dizziness, nausea, and vomiting. Skin sensitization and severe irritation and inflammation of the eyes, nose, and throat can also occur.

RECOMMENDED MEDICAL PRACTICES

• Medical surveillance program

Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control 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 and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. The occurrence of disease (a "sentinel health event," SHE) 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 surveillance program is intended to supplement, not replace, such measures.

A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, morbidity, and mortality data. This analysis may provide information about the relatedness of adverse health effects and occupational exposure that cannot be discerned from results in individual workers. Sensitivity, specificity, and predictive values of biologic monitoring and medical screening tests should be evaluated on an industry-wide basis prior to application in any given worker group. Intrinsic to a surveillance program is the dissemination of summary data to those who need to know, including employers, occupational health professionals, potentially exposed workers, and regulatory and public health agencies.

• Preplacement medical evaluation

Prior to placing a worker in a job with a potential for exposure to ethyleneimine, the physician 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, skin, liver, kidneys, and

nervous and respiratory systems. Medical surveillance for respiratory disease should be conducted by using the principles and methods recommended by NIOSH and the American Thoracic Society (ATS).

A preplacement medical evaluation is recommended in order to detect and assess preexisting or concurrent conditions which may be aggravated or result in increased risk when a worker is exposed to ethyleneimine at or below the NIOSH REL.

The examining physician should consider the probable frequency, intensity, and duration of exposure, as well as the nature and degree of the condition, in placing such a worker. Such conditions, which should not be regarded as absolute contraindications to job placement, include a history of chronic diseases of the liver or skin or concurrent dermatitis. The physician should obtain baseline values for tests of liver function.

• Periodic medical screening and/or biologic monitoring

Occupational health interviews and physical examinations should be performed at regular intervals. Additional examinations may be necessary should a worker develop symptoms that may be attributed to exposure to ethyleneimine. The interviews, examinations, and appropriate medical screening and/or biologic monitoring tests should be directed at identifying an excessive decrease or adverse trend in the physiologic function of the eyes, skin, liver, kidneys, and nervous and respiratory systems as compared to the baseline status of the individual worker or to expected values for a suitable reference population. The following tests should be used and interpreted according to standardized procedures and evaluation criteria recommended by NIOSH and ATS: Standardized questionnaires and tests of lung function.

• Medical practices recommended at the time of job transfer or termination

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic and laboratory tests which 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 to those expected for a suitable reference population. Because occupational exposure to ethyleneimine may cause diseases of prolonged induction-latency, the need for medical surveillance may extend well beyond termination of employment.

• Sentinel health events

Acute SHE's include: Contact and/or allergic dermatitis.

MONITORING AND MEASUREMENT PROCEDURES

• Method

Sampling and analysis may be performed by collecting ethyleneimine vapors with bubblers containing Folin's reagent followed by extraction with chloroform and analysis by high-pressure liquid chromatography. Direct-reading devices calibrated to measure ethyleneimine may also be used if available. A detailed sampling and analytical method for ethyleneimine may be found in the *NIOSH Manual of Analytical Methods* (method number 300).

PERSONAL PROTECTIVE EQUIPMENT

Chemical protective clothing (CPC) should be selected after utilizing available performance data, consulting with the manufacturer, and then evaluating the clothing under actual use conditions.

In operations involving "laboratory-type hoods" or in locations where ethyleneimine is contained in an otherwise "closed system" but is transferred, charged, or discharged into other normally closed containers, OSHA requires that workers: (1) be provided with and required to use clean, full-body CPC (smocks, coveralls, or long-sleeved shirts and long pants), shoe covers, and gloves prior to entering a regulated area; (2) be provided with and required to use approved respirators (a respirator affording higher levels of protection may be substituted); and (3) remove the protective clothing and equipment prior to exiting a regulated area, and at the last exit of the day, place used clothing and equipment in impervious containers for decontamination or disposal.

SANITATION

For closed system operations or in locations where ethyleneimine is contained in an otherwise "closed system" but is transferred, charged, or discharged into other normally closed containers, OSHA requires that workers: (1) wash their hands, forearms, faces, and necks prior to exiting the regulated area and before engaging in other activities, and (2) shower after the last exit of the day in designated facilities.

In isolated systems, such as a "glove box," OSHA requires that workers wash their hands and arms with soap and water upon completion of the assigned task and before engaging in other activities not associated with the isolated system.

If it is necessary for workers to wear protective clothing, OSHA requires that a clean change room be provided and equipped with showers and washing facilities. NIOSH recommends that lockers that permit separation of street and work clothes be provided for the worker.

Clothing which is contaminated with ethyleneimine should be removed immediately and placed in sealed containers for storage until it can be discarded or until provision is made for the removal of ethyleneimine from the clothing. If the clothing is to be laundered or cleaned, the person performing the operation should be informed of ethyleneimine's hazardous properties. Reusable clothing and equipment should be checked for residual contamination before reuse or storage.

Decontamination and disposal procedures should be established and implemented to remove ethyleneimine from materials and equipment. Contaminated material should be removed from regulated areas without further contamination of the facility.

OSHA requires that workers wash their faces, necks, hands, and forearms thoroughly with soap and water before eating, smoking, or using toilet facilities.

In regulated areas, OSHA prohibits the storage or consumption of food or beverages, the storage or application of cosmetics, the storage or smoking of tobacco or other smoking materials, or the storage or use of products for chewing.

OSHA prohibits the location of drinking fountains in regulated areas.

GENERAL CONTROL PROCEDURES

The following control procedures are derived from OSHA requirements as stated in 29 CFR 1910.1012:

Areas where ethyleneimine is manufactured, processed, used, repackaged, released, handled, or stored shall be designated as regulated areas, and entry into and exit from these areas shall be restricted and controlled. Only authorized workers are permitted access to regulated areas.

Workers authorized to enter regulated areas shall receive a training and indoctrination program including but not limited to the nature of the carcinogenic hazards of ethyleneimine, local and systemic toxicity, the specific nature of the operations which could result in exposure, and the purpose for and the significance of decontamination and emergency practices and procedures.

Entrances to regulated areas shall be posted with signs indicating that a cancer-suspect agent is present and that only authorized workers wearing appropriate protective clothing and equipment shall be admitted.

Appropriate signs and instructions shall be posted at the entrance to and exit from regulated areas to inform workers of the procedures that must be followed when entering or leaving a regulated area.

Open vessel system operations involving ethyleneimine which are not in an isolated system, laboratory-type hood, or other system affording equivalent protection against the entry of ethyleneimine into regulated areas, nonregulated areas, or the external environment are prohibited.

In operations involving "laboratory-type hoods" or in locations where ethyleneimine is contained in an otherwise "closed system" but is transferred, charged, or discharged into other normally closed containers, each operation shall be provided with continuous local exhaust ventilation so that air movement is always from ordinary work areas to the operation. Exhaust air shall not be discharged to regulated areas, nonregulated areas, or the external environment unless decontaminated. Clean makeup air shall be introduced in sufficient volume to maintain the correct operation of the local exhaust system.

Containers of ethyleneimine shall be identified as to contents and shall contain a hazard warning.

Regulated areas (with the exception of outdoor operations) shall be operated under negative pressure with respect to nonregulated areas. Local exhaust ventilation may be used to satisfy this requirement. Clean makeup air in equal volume shall replace air that is removed.

The introduction or removal of any equipment, materials, or other items to or from a regulated area shall be done in a manner that does not cause contamination of nonregulated areas or the external environment.

Decontamination procedures shall be established and implemented to remove ethyleneimine from materials, equipment, and the decontamination facility.

COMMON OPERATIONS AND CONTROLS

Common operations in which exposure to ethyleneimine may occur and control methods which may be effective in each case are listed in Table 1.

Table 1.—Operations and methods of control for ethyleneimine

Operations	Controls
During use in the manufacture of paper, textiles, adhesives, binders, petroleum refining products, rocket and jet fuels, lubricants, chemo-sterilant chemicals, chemotherapeutic agents, coating resins, varnishes, lacquers, agricultural chemicals, cosmetics, ion-exchange resins, photographic chemicals, colloid flocculants, and surfactants	Process enclosure, restricted access, local exhaust ventilation where appropriate, personal protective equipment, good housekeeping and personal hygiene practices, substitution with less toxic substances

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate emergency procedures. If a worker has contact with ethyleneimine, OSHA requires that the worker shower as soon as possible, unless contraindicated by physical injuries.

• Eye exposure

Where there is any possibility of a worker's eyes being exposed to ethyleneimine, an eye-wash fountain should be provided within the immediate work area for emergency use.

If ethyleneimine gets into the eyes, flush them 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

Where there is any possibility of a worker's body being exposed to ethyleneimine, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

If ethyleneimine gets on the skin, wash it immediately with soap and water. If ethyleneimine penetrates the clothing, remove the clothing immediately and wash the skin with soap and water. Get medical attention promptly.

• Rescue

If a worker has been incapacitated, move the affected worker from the hazardous exposure. 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.

SPILLS AND LEAKS

OSHA requires that hazardous conditions created by spills or leaks be eliminated and that potentially affected areas be decontaminated prior to the resumption of normal operations.

OSHA requires that affected areas of spills or leaks be evacuated as soon as an emergency has been determined.

OSHA requires that only authorized workers provided with and wearing clean, impervious garments (including gloves, boots, and continuous air-supplied hoods) enter areas of spills or leaks.

OSHA requires that workers authorized to enter areas of spills or leaks be decontaminated before removing the protective garments and hoods and showering.

If ethyleneimine 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 of liquids containing ethyleneimine, absorb on paper towels and place in an appropriate container.
4. Large quantities of liquids containing ethyleneimine may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container.
5. Liquids containing ethyleneimine may be collected by vacuuming with an appropriate system. If a vacuum system is used to remove ethyleneimine, there should be no sources of ignition in the vicinity of the spill, and flashback prevention devices should be provided.

WASTE REMOVAL AND DISPOSAL

U.S. Environmental Protection Agency, Department of Transportation, and/or state and local regulations shall be followed to assure that removal, transport, and disposal are in accordance with existing regulations.

RESPIRATORY PROTECTION

It must be stressed that the use of respirators is the least preferred method of controlling worker exposure and should not normally be used as the only means of preventing or minimizing exposure during routine operations. However, there are some exceptions for which respirators may be used to control exposure: when engineering and work practice controls are not technically feasible, when engineering controls

are in the process of being installed, or during emergencies and certain maintenance operations including those requiring confined-space entry (Table 2).

In addition to respirator selection, a complete respiratory protection program should be instituted which as a minimum complies with the requirements found in the OSHA Safety and Health Standards, 29 CFR 1910.134. A respiratory protection program should include as a minimum an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic environmental monitoring, maintenance, inspection, and cleaning. The implementation of an adequate respiratory protection program, including selection of the correct respirators, requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly.

Only respirators that have been approved by the Mine Safety and Health Administration (MSHA, formerly Mining Enforcement and Safety Administration) and by NIOSH should be used. **Remember! Air-purifying respirators will not protect from oxygen-deficient atmospheres.**

BIBLIOGRAPHY

- American Conference of Governmental Industrial Hygienists: "Ethyleneimine," *Documentation of the Threshold Limit Values and Biological Exposure Indices* (5th ed.), Cincinnati, 1986.
- American Conference of Governmental Industrial Hygienists: *TLVs® Threshold Limit Values and Biological Exposure Indices for 1987-88*, Cincinnati, 1987.
- American Industrial Hygiene Association: "Ethyleneimine" (rev. 1965), *Hygienic Guide Series*, Detroit, 1965.
- American Lung Association of San Diego and Imperial Counties: "Taking the Occupational History," *Annals of Internal Medicine*, 99:641-651, November 1983.
- Clayton, G.D., and Clayton, F.E. (eds.): *Toxicology*, Vol. IIA of *Patty's Industrial Hygiene and Toxicology* (3rd rev. ed.), John Wiley & Sons, Inc., New York, 1981.
- *Code of Federal Regulations*, U.S. Department of Labor, Occupational Safety and Health Administration, 29 CFR 1910.106, 1910.134, 1910.1000, 1910.1002, OSHA 2206, revised July 1, 1986.
- *Code of Federal Regulations*, U.S. Department of Transportation, 49 CFR 172.101, Transportation 49, revised October 1, 1982.
- Goldman, R.H., and Peters, J.M.: "The Occupational and Environmental Health History," *Journal of the American Medical Association*, 246:2831-2836, 1981.
- Grant, W.M.: *Toxicology of the Eye* (2nd ed.), Charles C. Thomas, Springfield, Illinois, 1974.
- Halperin, W.E., Ratcliffe, J., Frazier, T.M., Wilson, L., Becker, S.P., and Shulte, P.A.: "Medical Screening in the Workplace: Proposed Principles," *Journal of Occupational Medicine*, 28(8): 547-552, 1986.
- Hankinson, J.L.: "Pulmonary Function Testing in the Screening of Workers: Guidelines for Instrumentation, Performance, and Interpretation," *Journal of Occupational Medicine*, 28(10):1081-1092, 1986.
- Hawley, G.G.: *The Condensed Chemical Dictionary* (10th ed.), Litton Educational Publishing, Inc., New York, 1981.
- International Agency for Research on Cancer: *IARC Monographs on the Carcinogenic Risk of Chemicals to Man, Some Aziridines, N-, S-, and O-Mustards and Selenium*, Vol. 9, Lyon, France, 1975.
- Key, M.M., Director, National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control: *Proposed Permanent Standard for Certain Carcinogens*, at the Occupational Safety and Health Administration Hearing, U.S. Department of Labor, before Administrative Law Judge Burton Sternberg, Esquire, September 14, 1973.
- Leidel, N.A., Busch, K.A., and Lynch, J.R.: *Occupational Exposure Sampling Strategy Manual*, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-173, Cincinnati, 1977.
- Levy, B.S., and Wegman, D.H. (eds.): *Occupational Health: Recognizing and Preventing Work-Related Disease*, Little, Brown and Company, Boston, 1983.
- Mark, H.F., Othmer, D.F., Overberger, C.G., Seaborg, G.T., Grayson, M., and Eckroth, D. (eds.): *Kirk-Othmer Encyclopedia of Chemical Technology* (3rd ed.), John Wiley & Sons, Inc., New York, 1981.
- National Fire Protection Association: *National Fire Codes®* (Vol. 13), Quincy, Massachusetts, 1983.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control: "Ethyleneimine," *NIOSH Manual of Analytical Methods* (2nd ed., Vol. 5), Taylor, D.G. (ed.), DHEW (NIOSH) Publication No. 79-141, Cincinnati, 1979.
- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control: *Occupational Diseases—A Guide to Their Recognition* (rev. ed., 2nd printing), DHEW (NIOSH) Publication No. 77-181, 1978.
- National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control: *Registry of Toxic Effects of Chemical Substances* (Microfiche Edition), Sweet, D.V., and Lewis, R.J. (eds.), Cincinnati, April 1985.
- Parmeggiani, L. (ed.): *Encyclopedia of Occupational Health and Safety* (3rd ed.), International Labour Office, Geneva, Switzerland, 1983.
- Proctor, N.H., and Hughes, J.P.: *Chemical Hazards of the Workplace*, J.B. Lippincott Company, Philadelphia, 1978.
- Rom, W.N. (ed.): *Environmental and Occupational Medicine*, Little, Brown and Company, Boston, 1983.
- Rothstein, M.A.: *Medical Screening of Workers*, Bureau of National Affairs, Washington, DC, 1984.
- Rutstein, D.D., Mullan, R.J., Frazier, T.M., Halperin, W.E., Melius, J.M., and Sestito, J.P.: "Sentinel Health Events (Occupational): A Basis for Physician Recognition and Public Health Surveillance," *American Journal of Public Health*, 73:1054-1062, 1983.

- Sax, N.I. (ed.): *Dangerous Properties of Industrial Materials* (6th ed.), Van Nostrand Reinhold Company, New York, 1984.
- Scientific Assembly on Environmental and Occupational Health: "Evaluation of Impairment/Disability Secondary to Respiratory Disease," *American Review of Respiratory Diseases*, 126:945-951, 1982.

- Scientific Assembly on Environmental and Occupational Health: "Surveillance for Respiratory Hazards in the Occupational Setting," *American Review of Respiratory Diseases*, 126:952-956, 1982.
- Windholz, M. (ed.): *The Merck Index* (10th ed.), Merck & Co., Inc., Rahway, New Jersey, 1983.

Table 2.—Respiratory protection for ethyleneimine

Condition	Minimum respiratory protection*
Any detectable concentration	<p>Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode</p> <p>Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode</p>
Planned or emergency entry into environments containing unknown or any detectable concentration	<p>Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode</p> <p>Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive pressure mode</p>
Firefighting	Any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode
Escape only	<p>Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted organic vapor canister</p> <p>Any appropriate escape-type self-contained breathing apparatus</p>

* Only NIOSH/MSHA-approved equipment should be used.