OCCUPATIONAL SAFETY AND HEALTH GUIDELINE FOR ETHYLENE GLYCOL

INTRODUCTION

This guideline summarizes pertinent information about ethylene glycol 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 Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether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**

  $C_2H_6O_2$

- **Structure**

  CH_2OHCH_2OH

- **Synonyms**

  1,2-Dihydroxyethane; 1,2-ethanediol; 2-hydroxyethanol; ethane-1,2-diol; ethylene alcohol; ethylene dihydrate; glycol; monoethylene glycol; glycol alcohol; Lutrol-9; Macrogol 400BPC; Norkool; Dowtherm SR 1

- **Identifiers**

  1. CAS No.: 107-21-1
  2. RTECS No.: KW2975000
  3. DOT UN: None
  4. DOT label: None

- **Appearance and odor**

  Ethylene glycol is a combustible, slightly viscous, colorless liquid with a sweet taste and no odor.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

  1. Molecular weight: 62.1
  2. Boiling point (760 mm Hg): 197.6°C (387.7°F)
  3. Specific gravity (water = 1): 1.11 at 20°C (68°F)
  4. Vapor density: 2.1
  5. Melting/freezing point: -13°C (8.6°F)
  6. Vapor pressure at 20°C (68°F): 0.06 mm Hg
  7. Solubility: Miscible in water, ethanol, glycerol, acetic acid, and acetone; slightly soluble in ether; practically insoluble in benzene and its homologs, chlorinated hydrocarbons, petroleum ether, and oils.
  8. Evaporation rate: Data not available

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Education and Information Division

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

Reactivity

1. Conditions contributing to instability: Heat, sparks, and open flame. Ethylene glycol that is heated or misted into the air presents a moderate fire and explosion hazard.

2. Incompatibilities: Ethylene glycol can react dangerously with chlorosulfonic acid, oleum, sulfuric acid, and strong oxidizing agents such as perchlorates, peroxides, permanganates, chlorates, and nitrates.

3. Hazardous decomposition products: Toxic gases (such as carbon monoxide) may be released in a fire involving ethylene glycol.

4. Special precautions: None reported

Flammability

The National Fire Protection Association has assigned a flammability rating of 1 (slight fire hazard) to ethylene glycol.

1. Flash point: 115°C (240°F) (open cup); 111°C (232°F) (closed cup)

2. Autoignition temperature: 398°C (748°F)

3. Flammable limits in air (percent by volume): Lower, 3.2; upper, data not available

4. Extinguishant: Use water spray, dry chemical, "alcohol" foam, or carbon dioxide to fight fires involving ethylene glycol. Water or foam may cause frothing. Water may be ineffective, but it may be used to cool fire-exposed containers. If a leak or spill has not ignited, water spray may be used to dilute spills to noncombustible mixtures.

Fires involving ethylene glycol 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. Vapor explosion and poison hazards may occur indoors, outdoors, or in sewers. Vapors may travel to a source of ignition and flash back. Containers of ethylene glycol may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. If this is not possible, cool containers from the sides with water until well after the fire is out. Stay away from the ends of containers. Personnel should withdraw immediately if they hear a rising sound from a venting safety device or if a container is discolored as a result of fire. Dikes should be used to contain fire-control water for later disposal. If a tank car or truck is involved in a fire, personnel should isolate an area of a half a mile in all directions. Firefighters should wear a full set of protective clothing and self-contained breathing apparatus when fighting fires involving ethylene glycol. Structural firefighters' protective clothing may provide limited protection against fires involving ethylene glycol.

EXPOSURE LIMITS

- **OSHA PEL**

The Occupational Safety and Health Administration (OSHA) has not promulgated a permissible exposure limit (PEL) for ethylene glycol [29 CFR 1910.1000, Table Z-1].

- **NIOSH REL**

The National Institute for Occupational Safety and Health (NIOSH) has not issued a recommended exposure limit (REL) for ethylene glycol [NIOSH 1992].

- **ACGIH TLV**

The American Conference of Governmental Industrial Hygienists (ACGIH) assigns ethylene glycol a ceiling limit value of 50 ppm (127 mg/m^3), which should not be exceeded during any part of the working exposure [ACGIH 1993].

- **Rationale for limits**

The ACGIH limit is based on the risk of respiratory tract irritation associated with exposure to ethylene glycol [ACGIH 1991].

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Exposure to ethylene glycol can occur through inhalation, ingestion, eye or skin contact, and absorption through the skin.

- **Summary of toxicology**

1. *Effects on Animals:* Exposure to airborne concentrations of ethylene glycol causes eye and upper respi-

ratory tract irritation, and ingestion causes central nervous system depression, kidney and liver injury, and fetotoxic and developmental effects in experimental animals. In contact with the eyes or skin of rabbits, ethylene glycol caused irritation classified as mild [NIOSH 1994]. The dermal LD_{50} in rabbits is 9,530 mg/kg [NIOSH 1994]. The oral LD_{50} is 4,700 mg/kg in rats, 5,500 mg/kg in mice, and 6,610 mg/kg in guinea pigs [NIOSH 1994]. Dogs and cats given oral doses of ethylene glycol developed ataxia, vomiting, polydipsia, and seizures before losing consciousness [NLM 1993]. Exposure to a 12-mg/m^3 concentration of ethylene glycol continuously for 90 days, however, caused a moderate to severe degree of eye irritation in rabbits and rats [ACGIH 1991]. Dietary levels of ethylene glycol as high as 2 percent for 2 years caused decreased life span, calcium oxalate bladder stones, and kidney and liver damage in rats; the no-effect level in this study was no more than 0.2 percent in the diet (100 mg/kg/day) for 2 years [Clayton and Clayton 1981]. Several studies in rats and mice given oral doses of ethylene glycol during pregnancy have shown fetotoxic and developmental effects [NIOSH 1994].

2. *Effects on Humans:* Exposure to ethylene glycol vapor or mist causes eye, nose, and upper respiratory tract irritation in humans. In one report, reversible conjunctival inflammation occurred after ethylene glycol was splashed into a worker's eye [Hathaway et al. 1991]. By ingestion or percutaneous absorption, ethylene glycol causes central nervous system effects, liver and kidney damage, and cardiopulmonary effects. Loss of consciousness and nystagmus were reported among 9 of 38 women exposed to ethylene glycol vapor, and 5 of these workers also showed lymphocytosis [Clayton and Clayton 1981]. Throat irritation, headache, and backache were reported in human volunteers exposed to a mean concentration of ethylene glycol mist ranging from 1.4 to 27 ppm for 20 to 22 hours/day for 4 weeks. At a concentration of 60 ppm, symptoms were common; at 80 ppm, coughing and a sensation of tracheal burning became intolerable [ACGIH 1991]. Ingestion of a large amount (100 ml or more) of ethylene glycol produces three well-documented stages of toxicity. In Stage 1, which occurs within 30 minutes, nausea and vomiting, slurred speech, ataxia, nystagmus, lethargy, and a faint, sweetish odor on the breath develop. Coma, convulsions, and respiratory depression or cardiovascular collapse also may occur at this stage. In Stage 2, cardiopulmonary effects progress and cyanosis, pulmonary edema, and congestive heart failure may develop. In Stage 3, acute tubular necrosis develops, with oxaluria or anuria; these signs may progress to uremia and renal failure [Clayton and Clayton 1981; Hathaway et al. 1991].

- **Signs and symptoms of exposure**

1. *Acute exposure:* The signs and symptoms of acute airborne exposure to ethylene glycol include redness and irritation of the eyes and eyelids, sore throat, runny nose, cough, headache, and backache. Massive ingestion causes nausea; vomiting; slurred speech; ataxia; nystagmus; lethargy; impaired vision; a faint, sweet odor on the breath; coma; convulsions; elevated body temperature; elevated heart and respiratory rates; hypotension; agitation; confusion; cyanosis; tremor; areflexia; muscle twitches or contractions; crystalluria; hematuria; proteinuria; oxaluria; anuria; uremia; and cardiopulmonary collapse.

2. *Chronic exposure:* No signs or symptoms of chronic exposure to ethylene glycol have been reported in humans.

- **Emergency procedures**

WARNING!

Seek immediate medical attention for severely affected victims or for victims with signs and symptoms of toxicity or irritation!

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

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

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

3. *Inhalation exposure:* Move the victim to fresh air ***immediately***.

   If the victim is not breathing, clean any chemical contamination from the victim's lips and perform car-

diopulmonary resuscitation (CPR); if breathing is difficult, give oxygen.

4. *Ingestion exposure:* Take the following steps if ethylene glycol 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 touching 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*** 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, the location and proper use of emergency equipment, and methods of protecting themselves during rescue operations.

EXPOSURE SOURCES AND CONTROL METHODS

The following operations may involve ethylene glycol and lead to worker exposures to this substance:

—Use as antifreeze in cooling and heating systems

—Use as a vehicle for pharmaceutical preparations, food extracts, and flavoring essences and as a component of skin lotions, a substitute for glycerin, and an ingredient in various powders

—Use in electrolytic condensers as a solvent for boric acid and borates

—Use as a solvent in the paint and plastics industries

—Use in the formulation of printers' inks, stamp pad inks, and inks for ball point pens

—Use in the synthesis of safety explosives, glyoxal, unsaturated ester-type alkylated resins, plasticizers, elastomers, synthetic fibers (terylene and dacron), and synthetic waxes

—Use as an industrial humectant

The following methods are effective in controlling worker exposures to ethylene glycol, depending on the feasibility of implementation:

— Process enclosure

—Local exhaust ventilation

—General dilution ventilation

—Personal protective equipment

Good sources of information on 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 ethylene glycol, 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 eyes, upper respiratory tract, and skin. Medical monitoring for respiratory disease should be conducted using the principles and methods recommended by the American Thoracic Society [ATS 1987].

  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 ethylene glycol at or below the prescribed exposure limit. The 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 diseases of the eyes, upper respiratory tract, or skin.

- **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 ethylene glycol exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of ethylene glycol on the eyes, upper respiratory tract, or skin. 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. Although several of the metabolites of ethylene glycol can be detected in body fluids (serum, urine, blood) of exposed individuals, levels of these metabolites do not correlate well with airborne concentrations of ethylene glycol. Therefore, no biological monitoring test acceptable for routine use has yet been developed for ethylene glycol.

- **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

Determination of a worker's exposure to airborne ethylene glycol is made using a glass fiber filter in a Swinnex (TM) cassette, followed by a silica gel tube (520/260 mg sections, 20/40 mesh). Samples are collected at a maximum flow rate of 0.2 liter/min until a minimum collection time of 5 minutes is reached. As soon as possible after sampling, the filter is removed from the cassette and placed in a vial with a Teflon-lined cap containing 1 mL of 2% isopropanol in water. Analysis is conducted by gas chromatography using a flame ionization detector. This method is described in the OSHA Computerized Information System [OSHA 1993] and in Method No. 5500 of the *NIOSH Manual of Analytical Methods* [NIOSH 1984].

PERSONAL HYGIENE

If ethylene glycol contacts the skin, workers should flush the affected areas with plenty of water for 15 minutes, and then wash with soap and water.

Clothing contaminated with ethylene glycol should be

removed immediately, and provisions should be made for the safe removal of the chemical from the clothing. Persons laundering the clothes should be informed of the hazardous properties of ethylene glycol, particularly its potential to be irritating to the eyes, nose, and upper respiratory tract.

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

STORAGE

Ethylene glycol 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]. Since some containers can affect the color of this material, resin-coated steel, glass, aluminum, or stainless steel containers should be used for storage. Containers of ethylene glycol should be protected from physical damage and should be stored separately from chlorosulfonic or sulfuric acid, oxidizing agents such as perchlorates, peroxides, permanganates, chlorates, nitrates, moisture, heat, sparks, and open flame. Because containers that formerly contained ethylene glycol may still hold product residues, they should be handled appropriately.

SPILLS AND LEAKS

In the event of a spill or leak involving ethylene glycol, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup has been completed. 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. Remove all sources of heat and ignition.

4. Ventilate the area of the spill or leak.

5. Water spray may be used to reduce vapors, but the spray may not prevent ignition in closed spaces.

6. For small liquid spills, take up with sand or other noncombustible absorbent material and place into closed containers for later disposal.

7. For large liquid spills, build dikes far ahead of the spill to contain the ethylene glycol for later reclamation or 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**

  Ethylene glycol 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 ethylene glycol; there is no reportable quantity for this substance.

- **Community right-to-know requirements**

  Employers who own or operate facilities in SIC codes 20 to 39 that employ 10 or more workers and who manufacture 25,000 lb or more or otherwise use 10,000 lb or more of ethylene glycol per calendar year are required by EPA [40 CFR 372.30] to submit a Toxic Chemical Release Inventory form (Form R) to EPA reporting the amount of ethylene glycol 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 ethylene glycol 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 any 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 ethylene glycol 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 information 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 clothing should be worn to prevent skin contact with ethylene glycol. 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. The following materials have been tested against ethylene glycol and have demonstrated good-to-excellent resistance for periods of greater than 8 hr: natural rubber, butyl rubber, neoprene, polyvinyl chloride, nitrile rubber, polyethylene, Teflon, Viton, Saranex, and Barricade. 4H and Responder have demonstrated good-to-excellent resistance for periods of greater than 4 hr and less than 8 hr. Polyvinyl alcohol has a breakthrough time of 1 to 4 hr and should be used with caution against ethylene glycol.

If ethylene glycol 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 ethylene glycol might contact the eyes (e.g., through 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 ethylene glycol. Contact lenses should not be worn if the potential exists for ethylene glycol exposure.

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