

## Sources of Exposure

## Toxicokinetics and Biomonitoring

## Biomarkers/Environmental Levels

### General Populations

- The levels of exposure to ethylene oxide in the environment are generally low; levels may be higher near places where ethylene oxide is produced or used.
- Ethylene oxide enters the environment as a byproduct of tobacco smoke and when gas or diesel fuel are burned.
- Ethylene oxide is naturally formed by the oxidation of ethylene (which is also naturally formed by oxidation processes and the activity of intestinal bacteria). Therefore, the body naturally contains a certain amount of ethylene oxide, although it is very reactive and is rapidly metabolized and eliminated.

### Occupational Populations

- Workers involved in the production or use of ethylene oxide may be exposed by breathing it in the workplace or getting it on the skin.

### Toxicokinetics

- Ethylene oxide is readily absorbed following inhalation or oral exposure.
- Absorbed ethylene oxide is widely distributed in the body.
- Ethylene oxide readily attaches to proteins and DNA.
- Ethylene oxide is readily metabolized and excreted rapidly, mostly in the urine.

### NHANES Biomonitoring

- National survey of the U.S. general population conducted in 2015–2016 measured ethylene oxide hemoglobin adduct concentrations. The geometric mean values were 27.0 pmol/g hemoglobin in the nonsmoking population and 186 pmol/g hemoglobin in the cigarette-smoking population.

### Biomarkers

- *Biomarkers of Exposure:* Ethylene oxide can be measured in blood and alveolar air. The urinary metabolite, *S*-[2-hydroxyethyl]-mercapturic acid (HEMA), has been used as a biomarker of exposure to ethylene oxide. However, it is also a metabolite of other compounds and is not specific to ethylene oxide.
- *Biomarkers of Effect:* Ethylene oxide is a direct acting alkylating agent that can form adducts with macromolecules such as DNA and hemoglobin. Detection of these adducts can be used as biomarkers of effect, even in the absence of adverse effects. The primary DNA adduct is N7-(2-hydroxyethyl)guanine (7-HEG) and the primary hemoglobin adduct is hydroxylated *N*-terminal valine.

### Environmental Levels

#### *Air*

- Outdoor air: Air concentrations of ethylene oxide ranged from 0.136  $\mu\text{g}/\text{m}^3$  (0.075 ppb) to 0.407  $\mu\text{g}/\text{m}^3$  (0.224 ppb) in samples taken from October 2018 to September 2019 from 18 National Air Toxics Trend Stations and Urban Air Toxics Monitoring Networks.
- Indoor air: Not usually detected, but levels as high as 4  $\mu\text{g}/\text{m}^3$  (2.2 ppb) were found in 1 out of 50 residences sampled.

#### *Sediment and Soil*

- No data.

#### *Water*

- Surface water: Not usually detected, but a concentration of 2 mg/L was reported in effluent from a chemical plant.
- Ground water: No data.
- Drinking water: No data.

### Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2022. Toxicological Profile for Ethylene Oxide. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

# ToxGuide™ for Ethylene Oxide



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U.S. Department of Health and  
Human Services  
Public Health Service  
Agency for Toxic Substances  
and Disease Registry  
[www.atsdr.cdc.gov](http://www.atsdr.cdc.gov)



## Chemical and Physical Information

## Routes of Exposure

## Relevance to Public Health (Health Effects)

### Ethylene Oxide is Manmade

- Ethylene oxide is a colorless gas with a sweet, ether-like odor.
- Ethylene oxide is mostly used to produce other chemicals such as ethylene glycol.
- A small percentage of ethylene oxide produced is used in the sterilization or fumigation of certain equipment (particularly medical equipment), cosmetics, and food.

- Inhalation – Most likely route of exposure for the general population and workers involved in ethylene oxide production or use.
- Oral – Not a likely route of significant human exposure to ethylene oxide.
- Dermal – A possible route of exposure for workers involved in ethylene oxide production or use.

### Ethylene Oxide in the Environment

- Ethylene oxide breaks down slowly in air.
- Ethylene oxide in water or soil would likely evaporate rapidly, hydrolyze, or biodegrade.

**Health effects are determined by the dose (how much), the duration (how long), and the route of exposure.**

### Minimal Risk Levels (MRLs)

#### *Inhalation*

- An acute-duration (up to 14 days) inhalation MRL of 0.4 ppm was derived for ethylene oxide.
- An intermediate-duration (15–364 days) inhalation MRL of 0.07 ppm was derived for ethylene oxide.
- No chronic-duration inhalation MRL was derived for ethylene oxide.

#### *Oral*

- No acute-duration oral MRL was derived for ethylene oxide.
- No intermediate-duration oral MRL was derived for ethylene oxide.
- No chronic-duration oral MRL was derived for ethylene oxide.

### Health Effects

- Workers exposed to high levels of ethylene oxide in the air for short periods of time had lung irritation.
- Workers exposed to lower levels of ethylene oxide for various times reported having effects such as headaches, memory loss, numbness, nausea, and vomiting.

- Based on limited data, there is some evidence that exposure to ethylene oxide can cause a pregnant woman to lose a pregnancy.
- Animal studies indicate that fetal and postnatal body weight may be decreased following exposure to ethylene oxide.
- Irritation in airway passages, nervous system effects, and reproductive effects were reported in experimental animals that breathed ethylene oxide during several months to years.
- Kidney effects, adrenal gland changes, and anemia (low amount of red blood cells) have also been reported in animals that inhaled ethylene oxide for several months.
- Higher risks of some blood and breast cancers have been reported in workers exposed to ethylene oxide.
- Leukemia, brain tumors, lung tumors, and other cancers were found in mice and rats that breathed ethylene oxide.
- The Department of Health and Human Services (HHS) has determined that ethylene oxide is known to be a human carcinogen. The U.S. Environmental Protection Agency (EPA) has concluded that inhalation exposure to ethylene oxide is carcinogenic to humans.

### Children's Health

- Children exposed to ethylene oxide would be expected to experience effects similar to those expected in adults.