

Ethylene Oxide

INEOS Oxide

● Technical Data Sheet

Ethylene oxide is a colourless gas at ambient temperature which condenses when cooled to a colourless, mobile liquid boiling at 10.4°C. It is miscible in all proportions with water, alcohol, ether and many organic solvents. The vapours of ethylene oxide are extremely flammable and are toxic if inhaled.

Synonyms for ethylene oxide are epoxyethane, dimethylene oxide, ethene oxide and oxirane.

Its Chemical Abstracts Service number is 75-21-8.

Information on other products manufactured by INEOS is described in their respective publications. General overview of INEOS product portfolio is described in the Facts file, accessible on the website www.ineos.com.

● Commercial Information

Specifications

Specifications are available on request from your INEOS sales representative.

Packages

Ethylene oxide is supplied in bulk loads in road tankers and in rail tank wagons of the bottom loading/unloading type.

Storage

Carbon steel, provided that it has been rendered substantially rust-free, and stainless steel are suitable materials of construction for ethylene oxide storage systems. Cast iron cannot be relied upon for strength and must not be used. Copper or magnesium bearing alloys are not recommended since ethylene oxide may contain small quantities of acetylenic impurities which can react with these metals to form explosive products. Phenolic or other plastic linings should also be avoided.

Storage vessels and ancillary pipework should be of all welded construction. They should be designed to both reduce the possibility of trapping ethylene oxide between closed valves in stagnant pockets, and eliminate the chance of contaminants entering storage tanks either by liquid, vapour, or inert gas lines. In-line centrifugal pumps with mechanical seals are preferred and should be fitted with high temperature detection and cut-out devices.

Ethylene oxide is a highly flammable liquid and can easily be ignited. Its vapour also decomposes violently at high temperatures. Storage tanks should therefore be pressurised with a high integrity supply of pure inert gas (such as nitrogen) and be protected by an effective water spray system. Storage should be remote from operating plant, preferably in a low risk fire area. Drainage must not be connected into a public sewerage system but should be directed towards a remote and segregated bund provided with adequate dilution facilities.

Liquid ethylene oxide is very susceptible to polymerisation initiated at ambient temperature by acids, bases or catalysts such as anhydrous chlorides or iron, aluminium, tin and metal oxides. All equipment should thus be thoroughly cleaned of scale, rust and all other contaminants prior to the introduction of the liquid. Purely thermal initiation starts around 100°C and once started, iron is an efficient promoter. The polymerisation is highly exothermic and, if the temperature is not controlled, is self-accelerating leading to vaporisation of unreacted ethylene oxide and possibly to explosive decomposition of the vapour.

Well-defined procedures must be adopted for the transfer, loading and unloading of ethylene oxide. Flexible hoses can be used provided they are of stainless steel. Further information and advice on recommended loading unloading techniques will be provided on request.

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● Regulations

The storage, use and conveyance of ethylene oxide is covered by national regulations in almost all European countries. Details are available through the local sales offices of INEOS.

In the UK, the following Statutory Instruments apply:

SI 1972/917	Highly Flammable Liquids and LPG Regulations 1972.
SI 1976/2003	Fire Certificates (Special Premises) Regulations 1976.
SI 1982/1357	The Notification of Installations Handling Hazardous Substances Regulations 1982
SI 1984/1244	The Classification, Packaging and Labelling of Dangerous Substances Regulations 1984.
SI 1984/1902	The Control of Industrial Major Accident Hazard Regulations 1984.
SI 1988/1657	The Control of Substances Hazardous to Health Regulations 1988.
SI 1992/743	The Road Traffic (Carriage of Dangerous Substances in Road Tankers and Tank Containers) Regulations, 1992.

The international transport classifications are:

UN	Number 1040
	Class 2.3
	Subsidiary Risks: Class 2.1
ADR/RID	Class 2,4°(ct)
IMDG Code	Class 2(2.3)
IATA/ICAO	Class 2 - Subsidiary risks 6.1,3
Hazchem Code	2PE
Tremcard No.	TEC(R) 16

● Industrial Applications

Ethylene oxide is a commodity monomer manufactured by the vapour phase oxidation of ethylene. It contains a highly reactive epoxide bridge and is used as a basic “building block” to obtain a large number of useful products and intermediates. Typical of these are ethylene glycols, polyethylene glycols, glycol ethers, ethanolamines, ethylene cyanohydrin, hydroxyethyl cellulose and hydroxyethyl starch. A wide range of surface-active agents used in the textile, detergent and paint industries can also be derived from this monomer, as well as choline chloride which is an animal feed supplement. In addition, ethylene oxide is an important raw material in the production of polyether and polymer polyols which, together with various isocyanates, are major components used in polyurethane foam manufacture. Ethylene oxide is a fumigant and sterilising agent.

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● Properties

Physical properties

The data in this section refer to the pure oxide. Values for the commercial product may deviate slightly from these figures.

Molecular mass		44.05
Density of liquid at 20°C	kg/litre	0.882
Density of vapour at 20°C	kg/litre	0.00183
Freezing point	°C	-112.5
Boiling point at 1.013 bar	°C	10.4
Latent heat of vaporisation at the boiling point	kJ/kg	579
Critical temperature	°C	196
Critical pressure	bars	71.9
Critical volume	litre/kg mole	140
Coefficient of expansion at 20°C	per °C	1.64 x 10 ⁻³
Specific heat of gas at 20°C	kJ/kg°C	1.95
Specific heat of gas (1 atm; 34°C)	kJ/kg°C	1.10
Vapour pressure at 20°C	m bar	1448
Flash point (open cup)	°C	-18
Flammability limits in air		
lower	% volume	3
upper	% volume	100
Auto ignition temp in air at 1 atm	°C	429
Decomposition temp of pure vapour at 1 atm	°C	560
Heat of formation of vapour at 25°C	MJ/kg mole	-52.7
Heat of formation of vapour at 0°C	MJ/kg mole	-77.5
Heat of combustion of gas	MJ/kg mole	29.4
Heat of decomposition of gas	MJ/kg mole	83.7
Heat of polymerisation of liquid	MJ/kg mole	92.1
Refractive index n_D^{20} at 7°C		1.3597
Surface tension at 0°C	mN/m	27.6
Viscosity of liquid at 0°C	mPa.s	0.322

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● Safe Handling

The Material Safety Data Sheet for ethylene oxide summarises the pertinent information required for the safe handling and use of ethylene oxide and must be consulted.

● Handling Precautions

Ethylene oxide exhibits severe acute toxic properties and is extremely irritant to the eyes, skin and respiratory tract. The eyes are particularly susceptible to permanent damage from splashes, even to dilute solutions. Good working procedures and hygiene practices are therefore essential and precautions must be taken to avoid contact.

Chemical goggles and full-length rubber or polychloroprene gloves, together with boots made from similar materials should be worn during all operations. Chemical oversuits should also be used where there is significant potential for skin contact. Leather footwear should be avoided since this is permeable, while both PVC and nitrile rubber have very limited resistance to ethylene oxide. Self-contained breathing apparatus must be used when tackling leaks or where there is a risk of exposure to more than the permitted concentration of ethylene oxide in the workplace atmosphere. Safety showers and eye baths should be provided in case of an emergency. Contaminated clothing should be reworn only after washing thoroughly or following dry cleaning.

Equipment handling ethylene oxide, particularly in enclosed buildings, should be checked regularly for emissions of the vapour. Exposure must be prevented by the use of efficient and appropriately sited ventilation and extraction systems.

A Maximum Exposure Limit of 5 ppm (10 mg/m³) (8 hour reference period) has been assigned to ethylene oxide by the UK Health and Safety Executive (Guidance Note EH40/92) and therefore workplace concentrations must be kept as far as it is reasonably practicable below this figure. The current Threshold Limit Value (TLV) adopted by the American Conference of Governmental Industrial Hygienists (1985) is 1 ppm (2mg/m³) with the notation 'A2' drawing attention to ethylene oxide as being a substance suspected of having carcinogenic potential in humans. Compliance with the above hygiene standards should be confirmed by personal monitoring augmented where appropriate by area monitoring. Details of analytical methods are available on request.

The odour threshold of ethylene oxide is around 700 ppm. The odour, however, must not be relied upon to provide warning of the presence or absence of excessively high concentrations since fatigue of the sense of smell occurs rapidly following exposure.

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● Emergency Procedures

Fire	Large fires: Extinguish with water spray or alcohol foam. Small fires: Extinguish with water spray or dry chemical. Unless the leak can be stopped immediately, do not extinguish a leaking gas flame because of the possibility of explosive reignition. Keep equipment cool with water spray. Fire fighters must wear self-contained breathing apparatus and full protective clothing.
Product in eye	Immediately flood with copious quantities of water for 15 minutes, holding the eye open. Obtain urgent medical attention.
Product on skin	First remove contaminated clothing, then wash with large quantities of running water. In the absence of abundant running water, liquid should be allowed to evaporate rather than forming a strong ethylene oxide solution with inadequate water. Water solutions should be removed by immediate water washing. Obtain medical attention if irritation persists or blistering occurs.
Product inhaled	Remove from exposure, keep warm and at rest. If there is respiratory distress, give oxygen. If respiration stops, or shows signs of failing, apply artificial respiration. Obtain medical attention immediately.
Product ingested	Not applicable.
Spillage	Extinguish all sources of ignition and immediately evacuate all personnel from affected area. Contain, if possible, with sand or earth. Use water spray to disperse vapours. Personnel dealing with the spillages must wear full protective clothing including respiratory protection. Ethylene oxide, or its aqueous solutions, should not be discharged into streams, drains or sewers. Inform authorities if major spillage occurs.

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● Fire and Explosion Data

Ethylene oxide has a flash point of - 18°C and is therefore an extremely flammable liquefied gas. It is flammable in air at concentrations above 3% by volume. There is no upper limit as normally conceived, since exothermic decomposition replaces combustion at the higher ranges up to 100% vapour.

Because of its low boiling point and high flammability, ethylene oxide exhibits properties similar to that of a liquefied petroleum gas. An essential difference, however, is that it is fully miscible with water. Closed cup flash point determinations indicate that, at concentrations below 1% by weight the vapours are not flammable in air at ambient temperatures, i.e. leakage of ethylene oxide is rendered non-flammable by diluting 100 fold with water.

The vapour decomposes explosively if detonated, ignited or heated to about 560°C, even in the absence of air. Its auto-ignition temperature in air at atmospheric pressure is 429°C.

Ethylene oxide will not polymerise spontaneously under normal conditions of temperature and pressure. However, it will polymerise violently, with potential for explosion, if contaminated with aqueous alkalis, mineral acids, metal chlorides or metal oxides.

● Health Effects

Ethylene oxide vaporises rapidly at ambient temperatures so that exposure of personnel to vapour in the workplace atmosphere, rather than liquid contact, is the more likely hazard. Nevertheless, the liquid can persist in the open particularly under winter conditions.

Liquid splashes in the eye cause severe irritation and corneal injury. The vapour will also cause moderate eye irritation at high concentrations.

Liquid ethylene oxide has little effect on the skin provided the quantity is small, the contact of short duration and the area affected unconfined. Exposure to large quantities, however, may result in 'frostbite' burns. Occluded contact with the liquid, even of dilute solutions, causes irritation, swelling or burns although these effects may be delayed until several hours after contamination. Prolonged contact causes blisters and may cause headache, dizziness, nausea and vomiting. Allergic sensitisation has been reported following repeated exposure to ethylene oxide.

Exposure to ethylene oxide vapour at concentrations greatly above the hygiene standard causes irritation of the eyes and respiratory tract, together with headache, nausea, vomiting, laboured breathing and diarrhoea. Severe or repeated over-exposure may cause serious damage to the lungs (pneumonitis and pulmonary oedema) and central nervous system (convulsions, paralysis or coma).

Ethylene oxide is mutagenic in a wide variety of in vivo test systems and a proven animal carcinogen. It should therefore be regarded as a potential carcinogen for man.

Ethylene oxide is classified in Annex I of the Dangerous Substances Directive as a Category 2 carcinogen and Category 2 mutagen.

Ethylene oxide has been found to adversely affect the reproductive system and embryos of experimental animals. A relationship between such effects and exposure in humans has not been established. Peripheral neuropathy has also been observed in animals repeatedly exposed to high concentrations (several hundred ppm) of vapour.

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● Environmental Data

Ethylene oxide is slightly toxic to aquatic species TLm96 values in the range 10-100 mg/l. Furthermore it is likely to be inhibitory to biomass at concentrations of about 10-50 mg/l, but is, however, readily biodegradable below these concentrations as shown by the following data:

Bio-oxidation as % Theoretical O₂ demand (ThOD)

after	5 days	10 days	22 days
	5	22	52

where ThOD is 1.82 gm/gm

Ethylene oxide is also unlikely to bioaccumulate.

● Exclusion of Liability

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Further information is available from:

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