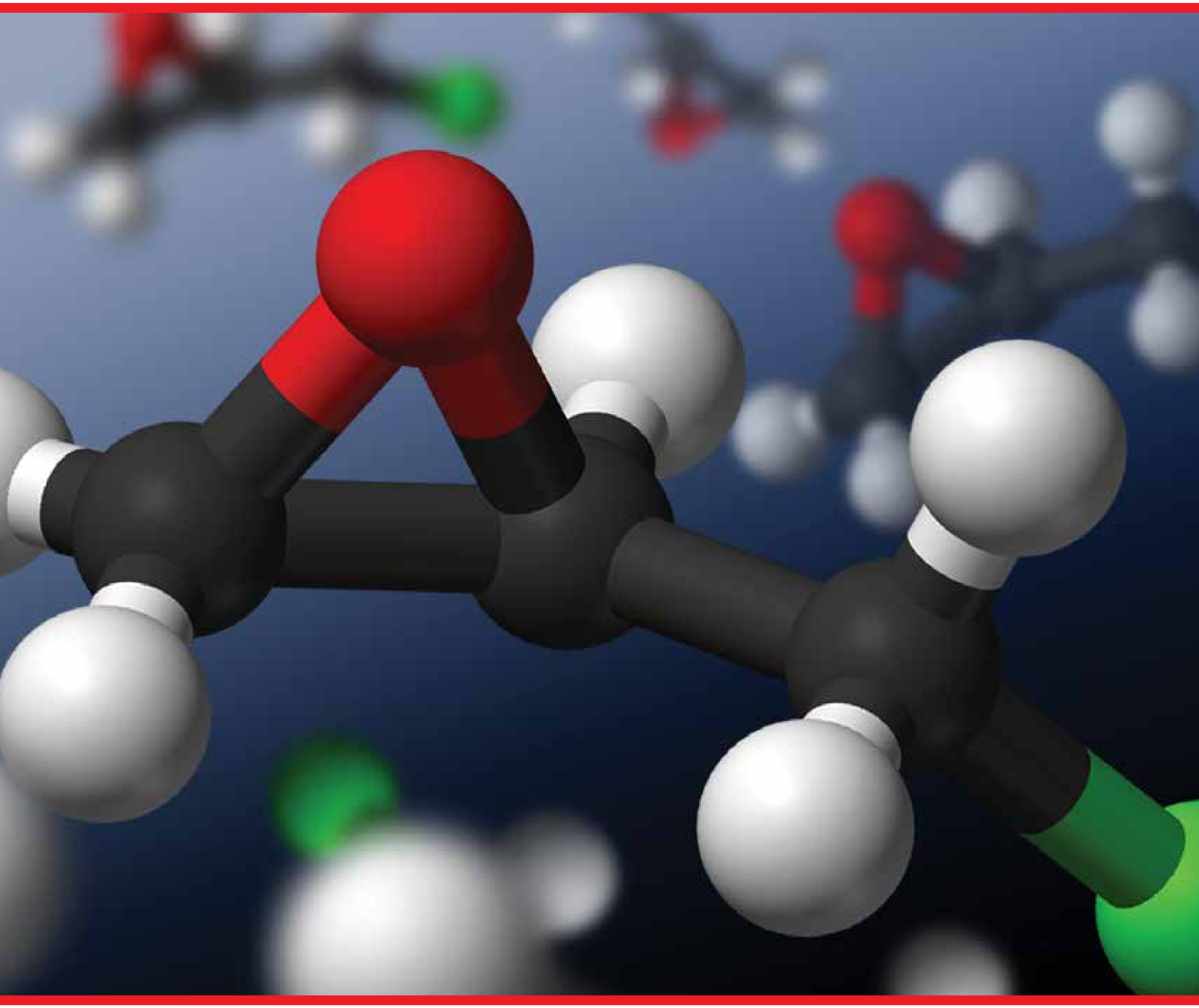
EPICHLOROHYDRIN

PRODUCT STEWARDSHIP MANUAL



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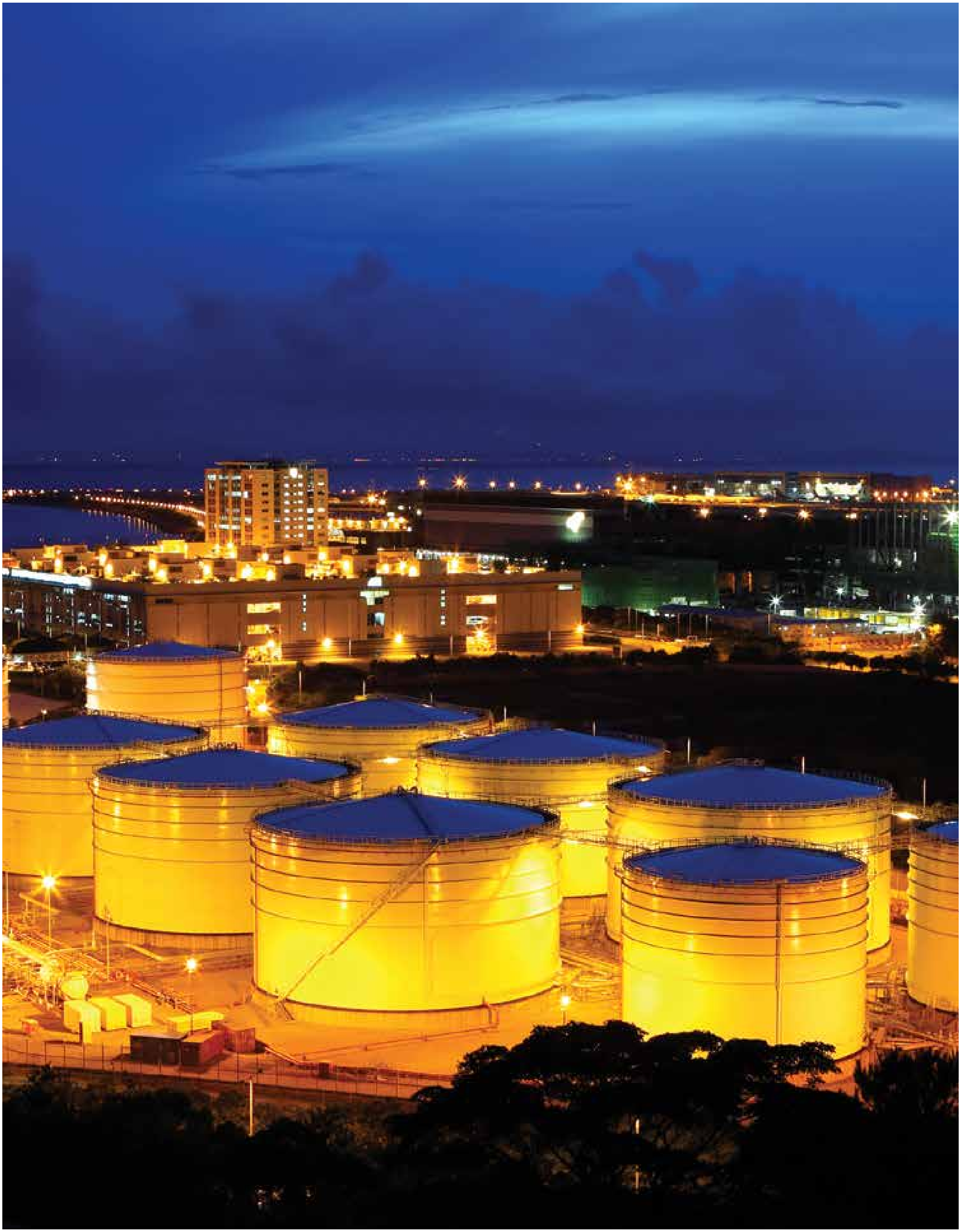


Introduction

Epichlorohydrin is a highly reactive chemical intermediate available from Olin. Olin is one of the largest producers of epichlorohydrin in the world, with a capacity of more than 450,000 metric tons/year (more than 1 billion pounds/year) from plants in Freeport, Texas, USA, and Stade, Germany.

In its pure form, epichlorohydrin is a clear, colorless liquid. The presence of both an epoxide ring and a chlorine atom in the molecule allows epichlorohydrin to readily undergo a variety of chemical reactions with many types of compounds. This versatility earns its wide use as a chemical intermediate.

Regardless of its uses, epichlorohydrin must be handled carefully to protect the health of employees, customers, the public, and the environment. Although your company is responsible for its own safety procedures, our goal is to make that task easier with this manual.

Read this manual prior to handling or using epichlorohydrin products, and use it as a training tool for new employees. For additional assistance, you can ask Olin to:

- Make a pre-delivery evaluation of your site and provide suggestions for improvement
- Conduct on-site training for your employees
- Attend the first delivery to assist in a safe and spill-free product transfer

We want to put our experience with epichlorohydrin to work for you.

Product Stewardship

Olin and its employees have a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our Product Stewardship philosophy by which we assess the health and environmental information on our products and take appropriate steps to protect employee and public health and our environment. Our Product Stewardship program rests with each and every individual involved with Olin products, from initial concept and research to the manufacture, sale, distribution, use, and recycling or disposal of each product.

Responsible Care®

Olin has a long-standing policy to ensure that its operations do not have an adverse impact on the community or the environment. To uphold this policy, Olin is committed to the guiding principles of Responsible Care®, a continuing effort by the chemical industry to improve the responsible management of chemicals.

Under Responsible Care, Olin follows the 10 Guiding Principles and Codes of Management Practices that cover all aspects of research, development, manufacture, distribution, transportation, use, and disposal of products. These principles also extend to prompt reporting, customer counseling, community awareness, support of external research, participation with government and others, and promotion of Responsible Care worldwide.

Olin recognizes that no single entity can protect the quality of all of our air and water. However, by working together on a global basis, the public, industry, and government can make the future brighter and safer.

There are joint European Chemical Industry Council (CEFIC)/the European Association of Chemical Distributors (FECC) Responsible Care guidelines available via CEFIC's web page, www.cefic.org, and on www.responsiblecare.org.

Customer Notice

Olin strongly encourages its customers to review both their manufacturing processes and their applications of Olin products from the standpoint of human health and environmental quality. To help ensure that Olin products are not used in ways for which they are not intended or tested, Olin personnel are prepared to assist customers in dealing with ecological and product safety considerations. Your Olin representative can arrange the proper contacts. Also, Olin product literature, including Safety Data Sheets (SDS), should be consulted prior to use of Olin products. For copies, contact your Olin representative or the Olin location nearest you.

Olin believes the information and suggestions contained in this manual to be accurate and reliable as of publication date. However, since any assistance furnished by Olin with reference to the proper use and disposal of its products is provided without charge, and since use conditions and disposal are not within its control, Olin assumes no obligation or liability for such assistance and does not guarantee results from use of such products or other information herein; no warranty, express or implied, is given nor is freedom from any patent owned by Olin or others to be inferred.

Information herein concerning laws and regulations is based on U.S. federal laws and regulations, except when specific reference is made to those of other jurisdictions. Since use conditions and governmental regulations may differ from one location to another and may change with time, it is the customer's responsibility to determine whether Olin's products are appropriate for the customer's use, and to assure that the customer's workplace and disposal practices are in compliance with laws, regulations, ordinances, and other governmental enactments applicable in the jurisdiction(s) having authority over the customer's operations.

Emergency Contact Information

This Product Stewardship manual contains important information about Olin Epichlorohydrin that will help you and your employees to safely handle, store, and dispose of this material.

If other raw materials are used in your system, be sure to request suggestions for handling, storage, and disposal from the appropriate suppliers prior to working with those materials.

For more information about Olin Epichlorohydrin, refer to the SDS or contact your Olin representative. See the Appendix for country-specific contacts and telephone numbers. For emergencies, call the Olin Emergency Response Centers (24-hour Help Desk).

Table 1: Global Emergency Contact List

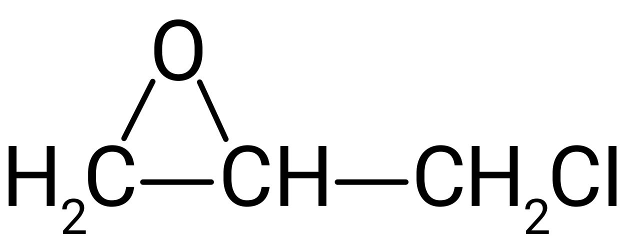
USA	+1 800 424 9300
Canada	+ 1 613 996 6666
Europe/Middle East/Africa/India	+ 32 3 575 55 55
Chinese Mainland	+ 86 532 83889090
Asia/Pacific	+ 65 6542 9595

Properties and Uses

Physical Properties

The chemical structure of epichlorohydrin is shown in Figure 1. Physical properties are provided in Table 2 and in Figures 2 and 3. Typical chemical reactions are provided in Table 3.

Figure 1: Chemical Structure of Epichlorohydrin



Chemical Reactivity

At high temperatures, epichlorohydrin can react violently and in some cases explosively (spontaneous polymerization) in the presence of certain substances. These substances may include:

- Acids
- Alcohols
- Alkalis
- Aluminum, magnesium, copper, tin, zinc, and other alloys
- Amines
- Ammonia
- Carbon monoxide
- Metal halides (such as iron III-chloride)
- Metal hydroxides
- Metal oxides
- Salts

Note: A mixture of epichlorohydrin and water, in which a two-phase mixture forms, will create a particular hazard. Over time, an exothermic reaction will start at the interface, which can generate enough heat to create a pressure build-up in the tank. Such mixtures must be disposed of promptly (see page 16, "Emergency Preparedness," for disposal information).

Properties and Uses

Table 2: Physical Properties of Epichlorohydrin[1]

Property	Description
Appearance	Colorless Liquid
Auto-ignition Temperature	416˚C (781˚F)
Boiling Point (1.013 kPa, 1 atm)	116.4˚C (241.6˚F)
CAS Number ID Number (Annex I*) EC Number (EINECS)	106-89-8 603-026-00-6 203-439-8
Chemical Name	1-chloro-2, 3-epoxypropane
Common Name	Epichlorohydrin (ECH or EPI)
Decomposition Temperature	217°C (423°F)
Density lb/gal, at 25°C g/l lb/ft^3	 9.8 1,174.5 73.3
Dielectric Constant, at 20°C	23
Empirical Formula	C_3H_5OCl
Flammable Limits, Volume in Air Lower Limit (%) Upper Limit (%)	 3.8 21
Flammable Limits, Volume Oxygen in Epichlorohydrin Lower Limit (%)	 11.6
Evaporation Rate	1.35 (butyl acetate = 1)
Flash Point, TCC (Tag Closed Cup)	31°C (87.8°F)
Heat Capacity J/mol, at 25°C J/mol, at 100°C	 131.9 (31.5 cal/mol) 166.2 (39.7 cal/mol)
Heat of Formation kJ/mol, at 25°C BTU/lb, at 77°F	 -149.0 (-35.6 kcal/mol) -693.1
Heat of Fusion kJ/mol, at 25°C Btu/lb, at 77°F	 10.5 (2,500 cal/mol) 49
Heat of Homopolymerization kJ/mol, at 25˚C	101.7 (24.3 kcal/mol)
Heat of Vaporization kJ/mol, at 25˚C Btu/lb, at 77˚F	 42.4 (10.1 kcal/mol) 196.9
Oxygen Content Required for Combustion, vol%[2]	11.6
Melting Point	-57.1˚C (-71.9˚F)

Table 2: Physical Properties of Epichlorohydrin (continued)[1]

Property	Description
Molecular Weight (g/mol)	92.53
Odor	Sweet, Pungent
Odor Threshold[3] Mean Odor Recognition (ppm) Odor Recognized by Majority of Individuals (ppm)	 10 25
Refractive Index n^{20}	1.435
Saturated Concentration (% volume in air at 20˚C (68˚F)	1.7
Solubility, at 25˚C Acetone Benzene Carbon Tetrachloride Diethylether n-Heptane Methanol In Water, at 20˚C (%) Water In, at 20˚C (%)	 Infinite Infinite Infinite Infinite Infinite Infinite 6.6 1.5
Specific Gravity	1.178
Specific Heat Ratio, at 25˚C	1.1131
Surface Tension N/cm, at 25˚C N/cm, at 100˚C	 36.4×10^{-5} 26.3×10^{-5}
Vapor Density, Relative (air = 1)	3.27
Vapor Pressure (kPa) 0˚C 25˚C 50˚C 100˚C	 0.46 (3.5 mmHg) 2.28 (17.1 mmHg) 8.36 (62.7 mmHg) 60.35 (452.7 mmHg)
Viscosity (mPa•s at 25˚C)	1.086 (1.086 cP)

[1]Typical properties, not to be construed as specifications.

[2]A maximum concentration of 8% oxygen is required for storage tanks, vessels and transportation equipment to ensure that the vapor never forms a flammable mixture.

[3]Odor threshold variously reported from less than 1 ppm to 25 ppm (See "Odor Threshold and Warning Properties," on page 10).

Properties and Uses

Figure 2: Vapor Pressure of Epichlorohydrin[1]

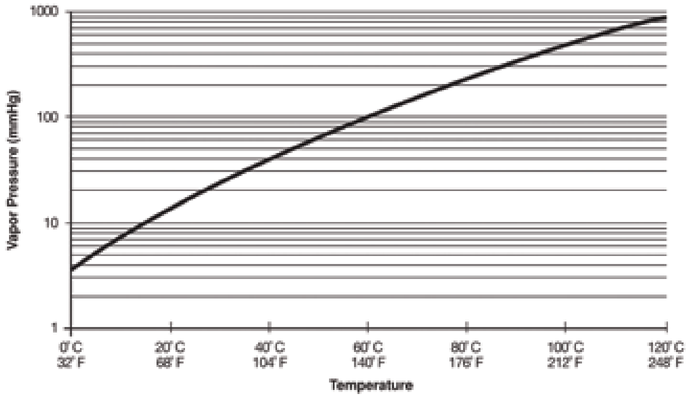
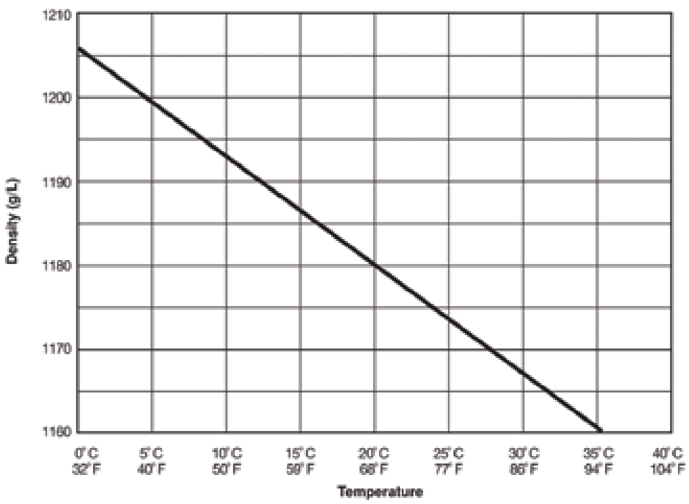


Figure 3: Density of Epichlorohydrin[1]



[1]These are typical values only, and are not to be regarded as sales specifications; users are advised to confirm for their operations.

Table 3: Typical Reactions of Epichlorohydrin

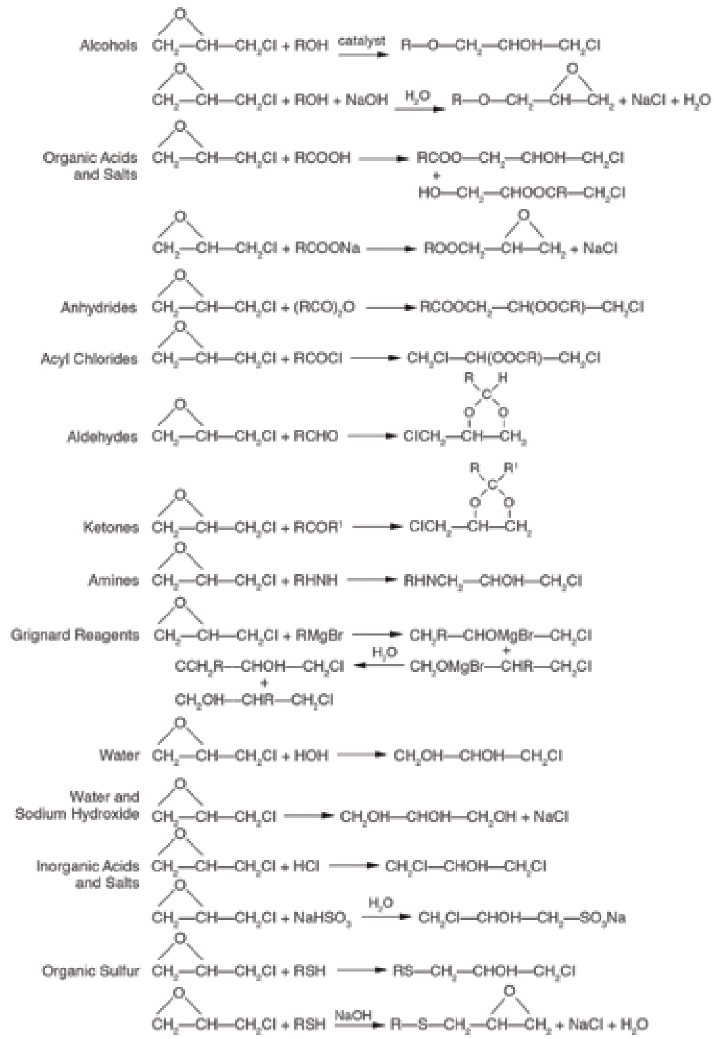
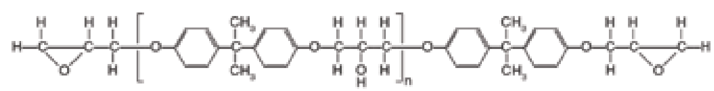


Figure 4: Basic Epoxy Resin Molecule



Properties and Uses

Product Uses

Epichlorohydrin is an extremely versatile chemical intermediate that finds its use in a wide variety of applications – from epoxy resins and textiles, to ion exchange resins rubbers, agricultural products, and more.

Epoxy Resins

Epichlorohydrin is primarily used to manufacture epoxy resins. Epoxy resins are generally produced by reacting a polyhydric phenol with an aliphatic chlorohydrin or simple aliphatic epoxide. The most familiar epoxy is obtained by condensing epichlorohydrin with bisphenol A, resulting in a basic epoxy resin molecule, such as that shown in Figure 4.

Major advantages of epoxy resins include corrosion resistance, solvent and chemical resistance, hardness, and adhesion.

Other derivatives of epichlorohydrin may be obtained by:

- Coupling this basic epoxy structure with materials containing an active hydrogen, such as aldehydes, polyamides, and polyamines
- Crosslinking it with amine or acid curing agents
- Esterifying it with short- or long-chain unsaturated acids

Textiles

In the textile industry, epichlorohydrin is used to modify the carboxyl groups of wool. The resulting product has a longer and improved resistance to moths. Epichlorohydrin also is used to prepare protein-modified, wool-like fibers, which have an affinity for acid dyes and which exhibit resistance to both mold and insects.

Further, epichlorohydrin is used to prepare dyeable polypropylene fibers and to dye polyolefin, polyacrylonitrile, polyvinyl chloride, polyvinyl alcohol, and other fibers. It is also used to impart wrinkle resistance and to prepare anti-static agents and textile sizings.

Derivatives of epichlorohydrin show utility as leveling, dispersion, softening, emulsifying and washing agents.

Papers, Inks, Dyes

Wet-strength paper sizing is prepared from either polyamides modified with epichlorohydrin or from the reaction product of epichlorohydrin and an alkylene amine.

Epichlorohydrin polyhydroxy compounds and their esters are useful in the production of special printing inks and textile print pastes. These products yield flexible films that are chemically inert to caustic soda and other chemical solutions.

Epichlorohydrin adducts are useful as filler retention aids, paper coatings, flocculants, and anti-static agents. Paper and paperboard products with improved printability, pigment retention, folding endurance, and gloss also are prepared with epichlorohydrin reaction products.

Ion Exchange Resins

Epichlorohydrin is used to produce both anion- and cation-exchange resins. Water-insoluble anion-exchange resins having good stability are prepared by reacting epichlorohydrin with ethylenediamine or a higher homolog. Strong-base anion-exchange resins can be produced by reacting epichlorohydrin with polymeric tertiary amines. Epichlorohydrin-based anion exchangers are used successfully to purify drinking water and to clean polluted air.

Cation-exchange resins are produced by condensing epichlorohydrin with polyhydroxy phenols and by sulfonating the product.

Surface Active Agents

Many epichlorohydrin-based, surface-active agents are synthesized by condensing the epichlorohydrin with a polyamine such as tetraethylene-pentamine, plus a fatty acid such as stearic acid.

The polyamine and fatty acid may be replaced with an alkali metal, starch, or other reactant. Sulfonated epichlorohydrin is occasionally substituted for epichlorohydrin.

Such products find use in cosmetics and shampoos, and as detergents, sudsing agents, water softeners, and demulsifiers.

Plasticizers

The reaction of epichlorohydrin with alcohols, alcoholates, or the sodium salts of stearic, oleic, palmitic, myristic, and other fatty acids yields products used as vinyl polymer plasticizers, solvents for food and flavoring, and plasticizers for polyurethanes.

Agricultural Products

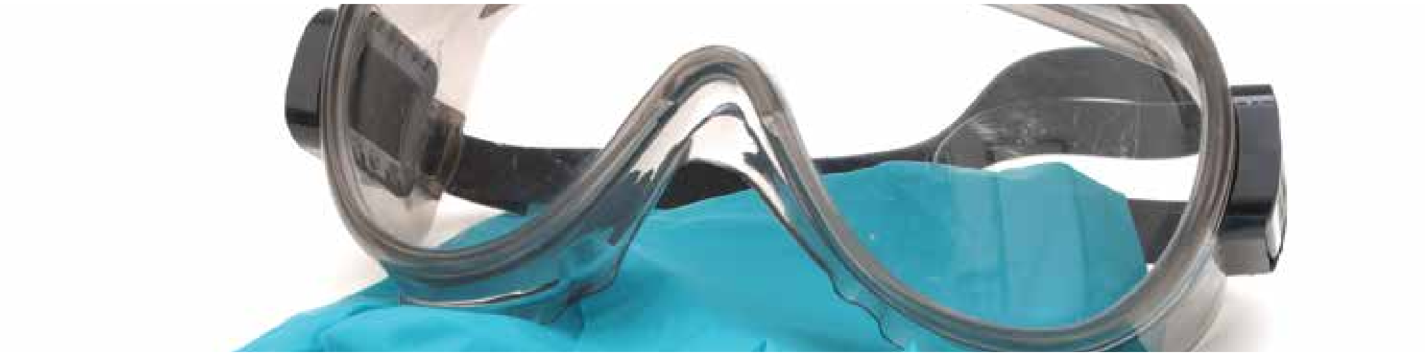
Biologically active compounds are prepared by reacting epichlorohydrin with alcohols or the sodium salts of alkylphenols. Such products have found effective use in insecticides, bactericides, and fungicides.

More Applications

Other applications for derivatives of epichlorohydrin include:

- Asphalt improvers
- Corrosion inhibitors
- Electrical insulation for wire
- Fire-retardant urethanes
- Hair conditioning rinses
- Liners for polyethylene bottles
- Linoleum and linoleum cements
- Lubricant additives
- Petroleum production aids
- Pharmaceuticals
- Photographic film bases
- Rubber latex coagulation aids
- Waterproofing compounds
- Zinc electroplating compounds

Health Hazards



The information in this section is general and should be used in conjunction with the most current epichlorohydrin SDS. A current SDS can be obtained from your Olin representative or by calling your local Olin Customer Care number, as found on the back of this brochure. The SDS should be reviewed prior to working with epichlorohydrin.

Potential Health Effects

Odor Threshold and Warning Properties

Epichlorohydrin has a chloroform-like, pungent smell with an odor threshold variously reported at values less than 1 part per million (ppm) to 25 ppm. Sensory perception studies have indicated that the mean threshold for odor recognition of epichlorohydrin is 10 ppm, and that at 25 ppm it is recognized by the majority of persons, which means that odor is not a reliable indicator of potential overexposure. Marked nose and eye irritation occurs at higher exposure levels.

ATTENTION: Workers must not rely on odor, or on eye and nose irritability, as a warning or indicator of potential overexposure.

Acute Toxicity

In the context of the "dose-time relationship," "acute" toxicity is the ability of a substance to cause harmful effects after only a single exposure – usually to a relatively high level or concentration of the substance in question.

Contact Effects

All direct contact with epichlorohydrin should be avoided. The following effects of epichlorohydrin on the skin and eyes should be carefully noted by all individuals working with this material.

Skin Contact

All skin contact with epichlorohydrin should be avoided; it is classified as corrosive. Epichlorohydrin is irritating and can be severely damaging to the skin, particularly if contact exceeds a few minutes. Exposure may not be apparent at first and irritation or damage may not develop for several hours. Prolonged contact will invariably cause serious chemical burns, even at low concentrations. Epichlorohydrin has caused allergic skin reactions in humans and is therefore classified as a skin sensitizer. Epichlorohydrin is also readily absorbed through intact skin in harmful amounts (the LD50[1] for skin absorption in rabbits is 515 mg/kg bw). Toxic systemic effects (liver and kidney) can result from repeated skin contact.

Eye Contact

All eye exposure with epichlorohydrin should be avoided; it can cause severe eye damage. Epichlorohydrin liquid will produce moderate irritation with corneal injury, while solutions of epichlorohydrin may cause more irritation and injury if the solvent carrying the epichlorohydrin is miscible with water. Epichlorohydrin vapor is also very irritating to the eyes.

Inhalation

All inhalation exposure to epichlorohydrin should be avoided. Epichlorohydrin vapor is irritating to the mucous membranes of the respiratory tract. Lung injury, which may be delayed, can result from inhalation of epichlorohydrin vapor. Epichlorohydrin is of moderate acute inhalation toxicity in animal models. The 1-hr LC50[1] value is estimated to be 3617 ppm for male rats and 2165 ppm (8.19 mg/L) for female rats. Liver and kidney injury can result from respiratory exposure or prolonged skin exposure to vapor.

Excessive vapor concentrations are readily attainable at room temperature and may cause unconsciousness and even death. At 25˚C (77˚F), epichlorohydrin has a vapor pressure of 2.26 kPa (17 mm Hg). This is equivalent to 22,000 ppm by volume.

[1]LC/LD50: estimated Lethal Concentration/Dose for fifty percent of animals exposed for specific time frame, or at a specific dose, typically during a two-week post-exposure observation time.

Ingestion

Epichlorohydrin is of moderate toxicity when ingested, based on animal data, with an estimated LD50 ranging from 175-282 mg/kg body weight. Although it is unlikely that acutely toxic amounts of epichlorohydrin would be ingested in the course of ordinary operations, should appreciable amounts be willfully or accidentally ingested, serious injury, including death, could result. Therefore, epichlorohydrin should be kept in the original containers (appropriately labeled), which should be closed and kept away from persons inexperienced with proper handling and use.

Burn Potential

The chemical burn potential with epichlorohydrin is well-known and identified in the SDS as a hazard.

Indeed, in an actual chemical burn incident, a worker wearing leather boots received a small splash on his impervious outer (slicker) suit during a truck off-loading operation. The worker washed the contamination from the suit shortly after the incident and again before storing the suit. He was unaware that a minor contamination of his boot had occurred. Approximately eight hours after the exposure, the worker noted itching on one of his feet. He noted three irritating red spots on his foot, but did not recognize them as an epichlorohydrin burn and put the leather boot back on his foot. The following morning, the worker awoke with a very swollen foot and a large blister across the area where the irritation was first observed. A medical investigation indicated that he had a severe burn which was believed to be caused by the very small epichlorohydrin exposure that occurred on the previous day, through his contaminated boot. The burn required skin grafts and eight weeks to heal.

The following observations come from such examples where unrecognized exposure from contaminated shoes resulted in significant burns:

- Leather does not offer suitable protection when handling epichlorohydrin and may magnify the burn potential
- Even an apparently insignificant exposure can lead to a serious burn if the contact continues for an extended period of time
- After leather is contaminated, it cannot be decontaminated and therefore must be destroyed
- The specific manufacturer's data on personal protective clothing (e.g., gloves, boots, and slicker suits) should be reviewed to ensure their suitability for use
- All terminal valves and fittings should be plugged to reduce the likelihood of an accidental exposure

Chronic Toxicity – Systemic Effects

"Chronic" toxicity describes the ability of a substance to cause harmful effects only after many repeated exposures over an extended period of time – usually to a lower level or concentration of the substance in question.

Repeated inhalation of epichlorohydrin vapor has resulted in liver and kidney injury to laboratory animals. In animal studies, a reversible decrease in fertility was observed in male rats; however, a number of epidemiological studies which investigated epichlorohydrin exposure and health effects in workers have shown no association with reproductive effects.

Mutagenicity and Cancer Information

Epichlorohydrin has been tested for mutagenicity in many different systems, giving both positive and negative results. Although several key studies conducted in animals did not detect mutagenic effects from epichlorohydrin, there are animal genetic toxicity tests that were positive.

Epichlorohydrin has been shown to cause cancer in laboratory animals and is classified as a carcinogen in most regions; in the USA it is considered to be a potential carcinogen, specifically classified as B2 (Probable human carcinogen – based on sufficient evidence of carcinogenicity in animals) by US EPA and as 'Reasonably Anticipated To Be Human Carcinogen' by the US National Toxicology Program's (NTP) Report on Carcinogens, and for purposes of the Occupational Safety and Health Administration's (OSHA) hazard communication standard, 29 CFR 1910.1200. It is classified by the International Agency for Research on Cancer (IARC) as Group 2A (probably carcinogenic in humans). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies epichlorohydrin as class A3 cancer (confirmed animal carcinogen with unknown relevance to humans).

Under the Globally Harmonized System (GHS) for the European Chemicals Agency (ECHA) program of Registration, Evaluation, and Authorization of Chemicals (REACH), epichlorohydrin is classified as a Category 1B carcinogen, associated with the H350 risk phrase: May cause cancer.

Several epidemiological studies have been conducted on worker populations with exposure to epichlorohydrin; some indicated an excess in lung cancer but others did not; all were based on relatively small numbers. IARC (1999) concluded based on available epidemiology data that "There is *inadequate evidence* in humans for the carcinogenicity of epichlorohydrin," but that "There is *sufficient evidence* in experimental animals for the carcinogenicity of epichlorohydrin," thus a classification of Group 2A "Epichlorohydrin is probably carcinogenic to humans."

Teratology and Reproductive Effects

In animal studies, epichlorohydrin has been toxic to the fetus, but only at doses that were toxic to the mother, and has been shown to interfere with fertility in males. These effects were reversible.

Exposure Limits

Government exposure limits are subject to periodic revision.

Occupational Exposure Levels (OELs) have been determined for epichlorohydrin by many authorities and regions. The Occupational Safety and Health Administration (OSHA) has established its permissible exposure limit (PEL) for epichlorohydrin at 5 ppm for an 8-hr workday (40 hr/week). The American Conference of Governmental Industrial Hygienists (ACGIH) has recommended a threshold limit value (TLV) of 0.5 ppm epichlorohydrin in air based on a time-weighted average (TWA) of an 8-hour workday; ACGIH has assigned a SKIN notation to epichlorohydrin. The European Union ACSH proposed a binding OEL of 1.9 mg/m^3 in 2012; this has not been finalized. The Derived-No-Effect-Level (DNEL) for epichlorohydrin, described in the European Chemicals Agency (ECHA) IUCLID, developed under the EU Registration, Evaluation, and Authorization of Chemicals (REACH) regulation, is 1.52 mg/m^3 for long term systemic effects. Also, while epichlorohydrin has a chloroform-like, pungent smell, the odor threshold has been estimated to fall between 1 and 25 ppm. Thus, olfactory detection of the presence of epichlorohydrin is not adequate to protect against overexposure.

Note: The National Institute for Occupational Safety and Health (NIOSH) listing for the vapor concentration considered immediately dangerous to life and health (IDLH) is 75 ppm for epichlorohydrin (see the NIOSH Pocket Guide to Chemical Hazards, or visit their website at www.cdc.gov/niosh/npg/npg.html).

Further information on the health and environmental effects of epichlorohydrin can be reviewed on the International Programme on Chemical Safety (IPCS) INCHEM document: www.inchem.org/documents/ehc/ehc/ehc33.htm.

Health Hazards

Exposure Control

Although epichlorohydrin has a very high vapor pressure, it can be controlled to maintain vapor concentrations well below occupational exposure limits (see Table 4). This should be achieved through properly designed, leak-tight product handling systems. Good ventilation is important; whenever possible, the epichlorohydrin handling facilities should be located outdoors to maximize natural ventilation. However, good ventilation cannot replace a closed, leak-tight system. Olin can provide information about the equipment used in our operations (see "Storage and Equipment," page 22).

All aspects of the handling operation, from delivery through reaction to disposal, must be carefully scrutinized for exposure potentials. Activities such as sampling should receive particular attention. Measures that prevent exposures should be thoroughly explored. These include the use of vapor return lines during product transfer, the dry disconnect style of fittings for transfer hoses, closed loop sampling systems, and the like.

Systems also must be designed to accommodate safety showers and eye washes in the immediate area **(less than 8 meters [26 feet] apart)** where exposures are likely, such as truck or rail car off-loading stations and locations where samples are taken. Showers and eye washes should be located so that workers whose vision is impaired by an exposure can easily find them.

When respiratory protection is required for certain operations, use an approved full face air-purifying respirator or a positive-pressure supplied air respirator, depending on the potential airborne concentration. If air-purifying respirator is used, it should be fitted with a fresh cartridge for organic vapors.

Note: Used cartridges should be destroyed due to the poor odor-warning properties of epichlorohydrin which make odor an unreliable indicator of chemical breakthrough.

For emergencies and other conditions in which the exposure guideline may be greatly exceeded, use an approved positive-pressure self-contained breathing apparatus (SCBA) or a positive-pressure supplied air respirator with an auxiliary SCBA.

Table 4: Key Regional/Country Occupational Exposure Level (OEL) Values for Epichlorohydrin

Country/Region	OEL	Units	Comments
US: OSHA PEL	5	ppm	19 mg/m³ TWA
ACGIH	0.5 (1.9)	ppm (mg/m³)	TLV-TWA (8 hr); A3 (Confirmed Animal Carcinogen with Unknown Relevance to Humans) ACGIH, 2001
European Union	1.9	mg/m³	Proposed as Binding OEL by ACSH in 2012
*DNEL	1.52	mg/m³	Protective for Systemic Long-Term and Local Effects

*DNEL: Derived No Effect Level: level of exposure to the substance above which humans should not be exposed; risk to humans is considered to be adequately controlled if the exposure levels do not exceed the appropriate DNEL.

For hand protection use chemical-resistant gloves at all times. Examples of gloves resistant to this material include butyl rubber and polyvinyl alcohol gloves.

Tanks and reactors must not be entered until they have been washed, purged, and tested for the presence of epichlorohydrin vapor (see proposed washing and tank entry procedures in section "Storage and Equipment," pages 25-26). Safe oxygen concentrations (19.5-23.5 percent) should be demonstrated with an oxygen meter test.

Air Monitoring

Due to its toxicity, high vapor pressure, and corrosive nature, epichlorohydrin can be safely handled in closed systems only. Because epichlorohydrin can be absorbed through the skin in toxic quantities, it is particularly important to avoid skin contact with vapor or liquid. All operations must be designed with engineering controls to minimize personnel exposure (see "Storage and Equipment," page 22). Operations such as sampling, which are often considered "open-system" operations, should also be designed to avoid exposure.

To ensure that epichlorohydrin is effectively contained, a formal air monitoring program should be designed and implemented by a qualified industrial hygienist. This is particularly important for epichlorohydrin, which has poor odor-warning properties (see "Odor Threshold," page 10). The odor-warning properties are not adequate indicators of an overexposure potential.

The industrial hygienist should consider all aspects of the operation, including work environment and job tasks. When changes are made in procedures or equipment, exposure assessments should be performed to verify containment. Talk with an Olin representative for more information.

Preventive Examinations

Before workers are assigned to epichlorohydrin handling operations, they should be screened with a complete pre-placement examination.

Note: Individuals with medical conditions that involve impairment of the liver, kidney, heart, or respiratory tract (which may include impairment due to abuse of alcohol) may be restricted from being assigned to jobs where exposure to epichlorohydrin could occur and create additional organ stress. For all workers assigned to positions where epichlorohydrin exposure could occur, annual examinations with special attention to lung, liver, and kidney functions are suggested.

Handling Instructions

All employees involved in the handling of epichlorohydrin should receive instructions before they start working with this substance. These instructions should be about the specific hazards of this chemical and decontamination procedures in the event of overexposure.

Workers should be cautioned not to breathe epichlorohydrin vapor. Odor does not give adequate warning of an overexposure situation (see "Odor Threshold" on page 10).

First Aid

Decontamination, First Aid, and Physician Notes

Any symptoms of exposure to epichlorohydrin, such as eye or respiratory irritation or skin rashes, should be reported immediately. Do not wear leather articles such as shoes, belts or watch bands, since leather cannot be decontaminated and can increase localized burn potential by holding the epichlorohydrin against the skin. Contaminated shoes or other articles of clothing should be removed immediately and discarded.

Note: Be sure to physically destroy any such contaminated article to ensure that it is not reused by other individuals.

In the Event of Exposure

- Remove the patient from the exposure area immediately
- Start thorough decontamination procedures at once
- See a physician

Decontamination

- Eye exposure requires immediate and thorough decontamination by irrigating the eye with low-pressure water continuously for at least 15 minutes
- Skin contact with the liquid is irritating and capable of causing skin burns. Skin exposure requires immediate showering with copious amounts of water for at least 15 minutes. Use soap if available.
- Contaminated clothing should be removed immediately, while showering. The clothing should be destroyed and not be re-used.
- Leather goods (shoes, belts, and other) cannot be decontaminated

Contaminated leather goods should be physically destroyed to prevent accidental reuse.

First Aid

- Remember, if respiratory distress develops, move the affected person to fresh air. If the person is not breathing, give artificial respiration. If breathing is difficult, oxygen should be administered by qualified personnel.
- Do not induce vomiting. Call a physician and/or transport to an emergency medical facility.
- Never give an unconscious person anything by mouth or attempt to induce vomiting
- In all cases, secure medical attention at once

Physician Notes

Skin contact with the liquid is irritating and capable of causing delayed skin burns. These may escalate to deep second-degree burns with little or no warning. If a burn is present, treat it as any thermal burn after decontamination.

Repeated skin contact or even single skin exposure, even at a low dose, can lead to sensitization and allergic reactions.

If respiratory distress develops, rest and oxygen administration may be helpful. Lung function should be assessed following a significant single or intermittent inhalation exposure. Persons receiving significant exposures should be observed for 24-48 hours for signs of respiratory distress. Any significantly exposed individual should be monitored for liver and kidney function for at least 60 days. Treatment is symptomatic and supportive if liver or kidney injury occurs. Chemical burns of the eye should be treated by a physician experienced in dealing with chemical eye injuries, but only after immediate and adequate decontamination with water.

If lavage is performed, endotracheal and/or esophageal control is suggested. Danger from lung aspiration must be weighed against toxicity when considering emptying the stomach. There is no specific antidote for epichlorohydrin. Provide supportive care. Treatment should be based on the judgment of the physician and the patient's reactions.

Environmental Considerations

Environmental Information

The use pattern of epichlorohydrin in epoxy resins and as an industrial intermediate in closed systems indicates a limited potential for exposure and thus limited potential for damage to the environment.

Epichlorohydrin is unlikely to persist in the environment. It hydrolyzes (breaks down) in water and is degraded in the air by hydroxyl radicals. It is considered readily biodegradable (BOD_{20} >40%), which suggests that it will be removed from water and soil environments, including removal by biological wastewater-treatment facilities.

Epichlorohydrin is not likely to accumulate in the food chain (bioconcentration potential is low) and is considered slightly to moderately toxic to fish and other aquatic organisms on an acute basis.

Emergency Preparedness

Although the chemical industry has one of the highest safety records, it is very important to put an effective, well-developed plan in place to ensure quick and effective response to emergencies. Emergency preparedness should consider all aspects of emergency situations that may occur on the site, in the surrounding community, or in the community at large.

This section and provides specific information about spills, fire-fighting, and associated waste disposal.

Emergency Preparedness

Fire-Fighting Guidelines

Fire Hazards

Epichlorohydrin is a flammable liquid and its vapor forms explosive mixtures with air.

Although the lower limit for oxygen concentration for epichlorohydrin flammability is 11.6 percent, Olin requires the concentration to be below 8 percent as a safety factor.

Table 5: Flammability Limits for Epichlorohydrin

Flammability Limits	LFL Lower Limit	UFL Upper Limit
Epichlorohydrin in Air	3.8%	21%
Oxygen in Epichlorohydrin Vapor	11.6%	–

Hazardous Combustion Products

During a fire, smoke may contain the original material in addition to combustion products of varying composition which may be toxic and/or irritating. Combustion products may include and are not limited to: hydrogen chloride, carbon monoxide, and carbon dioxide.

The flash point of epichlorohydrin is 31˚C (88˚F), Tag Closed Cup (TCC). Exotherm begins at 325˚C (617˚F) and the auto-ignition temperature is 416˚C (781˚F). The vapor is heavier than air and may travel considerable distance to a source of ignition and then flash back. The material is moderately soluble in water (6.6 percent at 20˚C/68˚F).

Fire-Fighting Methods

Use water fog, dry chemical, alcohol foam, or carbon dioxide when fighting fire. Use water to keep fire-exposed containers cool. If a leak or spill has not ignited, use water fog to disperse the vapors and to provide protection for workers attempting to stop a leak. Water fog may be used to flush spills away from potential ignition sources.

Wear a positive-pressure, self-contained breathing apparatus if contact with the vapors is possible; wear full protective clothing (see "Health Hazards" on pages 11-12).

For more information, review the local and country codes for fire protection such as the National Fire Protection Association (NFPA), www.nfpa.org, the European EN standards or the global International Electrical Council standards (IEC).

Spill Clean-Up

Degradation in the Environment

Epichlorohydrin is slightly toxic to aquatic organisms and moderately toxic to algae. It may also be moderately toxic to mammalian wildlife.

Epichlorohydrin is a mobile, volatile liquid with a water solubility of approximately 6.6 percent (66 g/l). Epichlorohydrin hydrolyzes in distilled water at a rate of 9.75×10^{-7} s^{-1}, which corresponds to 50 percent hydrolysis in 8.2 days (see Mabey and Mill resource below).

It also reacts with other nucleophiles such as chloride or hydroxide, which could lead to a more rapid hydrolysis.

Studies by The Dow Chemical Company, in addition to other work by W. Mabey, T. Mill, A.L. Bridie, and S. Sasaki (see resources below), indicate that biodegradation is a major environmental process with 5-day Biological Oxygen Demand (BOD) values of 18 percent (Dow) and 14 percent (acclimated; Bridie). Biodegradation continues with BOD values of 43 percent and 53 percent after 10 and 20 days, respectively (Dow) and is significantly degradable in the Japanese Ministry of International Trade and Industry test (Sasaki).

Biodegradation can also take place in surface soil. The high water solubility and mobility makes it possible for epichlorohydrin to enter the ground water where biodegradation is expected to continue, but at a slower pace. The hydrolysis of epichlorohydrin will prevent it from being a ground water pollutant other than immediately after a large spill. In the aquatic environment, epichlorohydrin will hydrolyze, biodegrade, and volatilize.

In a wastewater treatment system, the same processes will take place, with hydrolysis playing a minor role due to the short residence time.

Overall, epichlorohydrin is relatively unstable in the air and water. However, when spilled, it may exert a toxic action before hydrolysis. Epichlorohydrin is inherently biodegradable and the bioconcentration potential is low. Contamination of soil and water should be minimized by spill containment and removal, whenever possible.

Absorbents

Dry sand or ground polypropylene materials are suitable absorbents for epichlorohydrin spills. The advantage of polypropylene-based absorbents lies in their ability to be incinerated without creating a large ash loading on the incinerator.

Clay-based absorbents should not be used since they react with the epichlorohydrin resulting in the evolution of heat. Heat from this reaction can result in spontaneous combustion since auto-ignition temperatures can be reached.

Other absorbents may be suitable, but should be tested prior to use for reactivity with epichlorohydrin.

For large spills, clean-up is often best handled with a vacuum truck. If this approach is used, the truck should be padded with an inert gas before vacuuming the spill. Care should be taken not to introduce air into the truck as liquid is vacuumed. This could create an explosive atmosphere in the vacuum truck. Consider that the vent of the vacuum truck will emit significant amounts of epichlorohydrin vapor, which could cause additional hazards (environmental or health).

Emergency Preparedness

Table 6: Fire Protection Standards

Item	North America	Europe	Pacific	Worldwide
Flammable and Combustible Liquids	NFPA No. 30	EN Standards	Country-specific Standards	–
Electrical Codes	NFPA No.70	EN Standards	Country-specific Standards	IEC Standards
Protection Codes	NFPA No. 780	EN Standards	Country-specific Standards	IEC Standards

The possibility of a two-phase water mix must be considered; the hazard caused by a reaction with epichlorohydrin can occur over time.

Note: Suppliers and their products identified in this Manual are referred to in good faith, but no endorsement is made. It is the customer's responsibility to research available suppliers and make the appropriate selection.

Waste Disposal

Epichlorohydrin is classified as a hazardous waste in every part of the world. The relevant country-specific SDS should be consulted for specific government requirements related to waste disposal. Customers are advised to check their local applicable government requirements.

Several methods of disposal are available, including incineration, bio-treatment, and chemical conversion. Applicable government requirements must be considered prior to selecting a method. Final disposal methods should be discussed with local authorities whenever possible.

All applicable government requirements regarding health, environment, and waste disposal must be observed. Contact Olin for additional information.

All quantities of epichlorohydrin – or waste material contaminated with epichlorohydrin – should be removed to an approved industrial waste disposal area. If epichlorohydrin is to be incinerated, only an approved incinerator suitable for handling chlorinated hydrocarbons can be used. During incineration, hydrogen chloride is produced and must be scrubbed out of the gas from the incinerator.

Water contaminated with epichlorohydrin should be drained to a controlled area. This contaminated water should be treated at an approved water treatment facility.

When a problem arises as a result of a major spill or equipment rupture, only properly protected and trained personnel should remain in the area to supervise response and cleanup.

Hydrolysis

The alkaline hydrolysis of dilute water solutions of epichlorohydrin to glycerine can, under certain circumstances, be a desirable way to handle very small quantities of waste.

In a solution of 4N NaOH, the highest reaction rate can be expected (half-life approximately 15 minutes).

Note: The hydrolysis reactions of epichlorohydrin generate heat and a pressure build-up is a serious concern if the reaction is done in a contained system. Under alkaline conditions, the hydrolysis of epichlorohydrin proceeds to glycerine through an intermediate: glycidol. 2,3-Epoxy-propan-1-ol (note that glycidol is also toxic). The reaction rate is relatively slow at room temperature and can take days or weeks, depending upon circumstances, to proceed completely to the final product, glycerine. The reaction rate increases at elevated temperature. Treating large amounts (>100kg) of epichlorohydrin with dilute alkali at ambient temperatures with subsquent heating can lead to an uncontrollable polymerization with excessive heat generation.

If hydrolysis is considered, tests should be run to determine the exact chemical make-up of the resulting mixture before proceeding with disposal. Large amounts of epichlorohydrin should be disposed of in an incinerator.

Note: Do not use sodium carbonate or other alkali as an absorbent for spilled epichlorohydrin.

Table 7: Epichlorohydrin Half Life, (T 1/2) in Water @ pH 7

Temperature (°C)	T 1/2 (h)
20	160
30	5

If removal of trace quantities of epichlorohydrin from equipment is the objective, the use of low- or medium-pressure steam should be considered as the first means to react it.

Hydrolysis at ambient temperatures at neutral or acid pH is not suggested because the reaction beyond the initially-formed chlorohydrins proceeds slowly.

Contact your Olin representative if you wish additional information or assistance.

Handling and Transportation

Delivery Procedures

This section reviews road shipments and rail shipments, and provides a delivery checklist for customer use.

Prior to delivery, customers should be prepared to safely receive and off-load Olin Epichlorohydrin.

Note: Olin will not make deliveries to sites with which we are not familiar or are not assured that personnel are capable of safe unloading and storage. In general, this means that Olin will not deliver to a site that has not been visited and reviewed by an Olin representative. Upon request, Olin technical personnel will review the engineering plans of a proposed new facility and provide feedback and suggestions.

It is important to carefully instruct all personnel involved in the handling of epichlorohydrin (including unloading operators) on the hazardous properties of this material. Because the degree of hazard in handling or unloading epichlorohydrin varies from one operation to another, individual situations should be carefully evaluated to determine the appropriate safety measures.

Epichlorohydrin is supplied in bulk quantities only. However, small samples (typically 0.5 liter) are also available after a screening process has ensured that the person requesting the sample is aware of the material's hazards and can handle the material safely. Bulk shipments are available in truck, rail car, barge, ship, and Intermodal ISO-containers as required.

All bulk vehicles are designed to handle a closed-loop vent return from the storage tank. The vehicles in North America are also designed with a dry break fitting on both the vapor return line (1.5-inch) and the liquid off-loading lines (2-inch) to facilitate an exposure-free transfer of product. These dry break fittings are very effective at reducing the spillage during connection and disconnection to only a few droplets of fluid. The dry break feature requires that customers have a matching fitting (see "Storage and Equipment," page 22).

Road Shipments

For road truck deliveries in North America, Olin uses a dedicated fleet of trucks owned and managed by a single carrier. This carrier employs only drivers who have received extensive training about the properties and hazards of epichlorohydrin and the procedure in which delivery equipment must be handled for a safe, spill-free delivery. These drivers can be a very useful resource to assist your operating personnel with trouble-free transfers.

In Europe and other regions, the truck quantity deliveries are made in dedicated intermodal containers ("ISO-containers," 23 metric tons, volume 25,000 liters) by a single carrier. A program of carrier appraisal and driver training is also in place.

Handling and Transportation

Figure 5: Dry Disconnect Style Fittings

1. Comes attached to bulk delivery vehicle off-loading line.
2. Connect to flexible hose.

Parts shown are:

- 1676 AN-SS-20
  2-inch (5.08-cm) stainless steel adapter with female National Pipe Thread and Chemraz seals
- 1773 D-SS-20
  2-inch (5.08-cm) stainless steel coupler with female National Pipe Thread and Chemraz seals

Parts not shown are:

- 1676 AN-SS-15
  1-1/2-inch (3.81-cm) stainless steel adapter with female National Pipe Thread and Chemraz seals
- 1773 D-SS-15
  1-1/2-inch (3.81-cm) stainless steel coupler with female National Pipe Thread and Chemraz seals

Photo courtesy of Civacon, P.O. Box 54907, Cincinnati, OH 45254, U.S.A., +1 (513) 528-2700

Figure 6: Container Bottom Valve, 3-inch BSP

Figure 7: Container Top Connections, DN50 and DN80

Photo courtesy of HOYER GmbH Hamburg, Germany, www.hoyer-group.com

Figure 8: Rail Car Top Connections

Photo courtesy of VTG AG, Germany, www.vtg-rail.de

Table 8: Fitting Sizes for all Means of Transport

Means of Transport	Region	Liquid	Gas	Remarks
Rail Car	North America	2-inch	1.5-inch	Dry-break Coupling
	Europe	DN100	DN50/DN80	Standard Flanges (top and bottom discharge)
Road Truck	North America	2-inch	1.5-inch	Dry-break Coupling
	Europe	–	–	Not Supported
Intermodal Container[1]	North America	2-inch	1.5-inch	Dry-break Coupling
	Europe	Top: DN100 Bottom: 3-inch BSP	DN50/DN80	Top: Flange See Figure 6
Vessel	–	–	–	On Request

[1]Intermodal containers are the preferred shipping mode for epichlorohydrin into other global regions. Contact our Customer Information Group (CIG) for more information.

Handling and Transportation

ISO-containers can be unloaded either from the top or from the bottom. The standard valves sizes on the top are DN80 for liquid and DN50 for vapor. The standard bottom valve type of an ISO-containers is a 3-inch BSP-coupling.

To minimize personnel exposure to epichlorohydrin, Olin requires customers to use their own dedicated hose permanently attached to their pumping system. For this reason, Olin does not supply hoses or truck pumps.

Olin Product Stewards can provide product safety training for your employees. Talk to your Olin representative for more information.

Rail Shipments

Olin also ships product in a dedicated fleet of rail cars. These cars are 20,000 gallon (80 metric tons) pressure cars set up for top off-loading only. In North America, these cars are all fitted with dry break fittings for both liquid and vapor return. The fitting size is 2 inches for liquid and 1.5 inches for vapor.

The dedicated rail cars in Europe can load 65 metric tons (70 m^3 volume) and are designed for top and bottom discharge. The sizes of the connection flanges in Europe are DN100 for liquid and DN50/DN80 for vapor.

Rail cars are not used in regions other than North America and Europe.

Delivery Checklist

The following checklist is designed to help you prepare for a first delivery of either a bulk truck, ISO-container or a rail car to a new facility. For specific information about hardware, see “Storage and Equipment” on page 22, or talk to your Olin Product Steward.

- Has an Olin Product Steward visited your facility and reviewed your bulk epichlorohydrin handling and storage facility? Has Olin agreed to deliver to your facility?

Note: Olin will not deliver to a facility without performing an on-site review to verify that it meets our required practices for bulk delivery.

- Have you arranged for an Olin Product Steward to attend the first delivery?
- Was the off-loading piping and valve system pressure-tested to ensure that it is leak-free? If water was used for the pressure test, how was the system dried? Was the off-loading pump tested with liquid after installation?

Note: Any water in the system will create quality and safety problems.

- Is a written off-loading procedure available to employees?
- Was the procedure reviewed by the off-loading operator? Will the operator use it as a checklist for off-loading?
- How will the vehicle be managed for spill containment? Are there valve position changes required to secure the containment system? If so, are they described in the off-loading procedure?

Note: Olin suggests a spill-containment volume great enough to hold the entire contents of the vehicle scheduled for off-loading.

- Are spotting, chocking, and brake securement requirements clearly identified?

Note: For trucks, the driver should have clear instructions to surrender the keys and leave the truck cab.

- Is the operator required to use all of the appropriate protective gear (e.g., impervious suit, impervious rubber footwear and gloves, hard hat, approved respirator) before off-loading?
- Are the safety shower and eye wash stations immediately accessible in the off-loading area? Are they tested before any connections are made to the vehicle?
- Is the off-loading area cordoned off or barricaded to keep unauthorized personnel and vehicles out?

Note: Are warning signs typically used for the mode of transport used to secure the unloading area?

- Has the vehicle’s electrical ground been verified?
- Has the off-loading operator received training on the hazards of the product and reviewed current SDS?
- Has the driver received appropriate training and instructions on the specific handling by the customer, if the driver is supposed to assist during offloading?

Olin can assist to help manage the training with the carrier personnel.

- Will a check be made of the vehicle’s number, seals, and product identification tag (on the off-loading line) to verify the product against both the delivery note and Certificate of Analysis?

Note: Product stencils/label and accompanying documents on rail cars also should be checked.

- Will a sample be drawn and analyzed prior to off-loading?

Note: Olin suggests sampling and testing to positively confirm the product in the vehicle as epichlorohydrin.

- What precautions will be taken to avoid personnel exposure? Is personnel protective equipment adequate?
- Are all lines and vessels properly labeled and identified?
- If connections have to be made on the top of the transport vehicle, is protection against falls adequate?
- Was the oxygen level in the storage tank checked and verified to be below 8 percent?
- Are all terminal lines plugged (blinded) to prevent spills from an accidental valve opening (e.g., sampling and blow-down lines)?
- Are a fire extinguisher and suitable absorbent material available in the immediate area?
- Is there a communication link to the control room? How will it be maintained during off-loading?
- Have calculations been made and confirmed to ensure that the load will fit into the available tank space?
- How will the transfer of the load into the tank be monitored to verify movement of product when the pump is started and to ensure that the product is going to the correct location? How will the movement of vapors through the vapor return line to the vehicle be established and verified?

Handling and Transportation

Note: Truck trailers and Intermodal containers are particularly susceptible to damage from negative pressure and will collapse if not vented. The vehicle safety system may provide an audible warning alarm as it starts to relieve and suck air into the trailer. At any sign of safety valve relief, the transfer should be stopped immediately.

- Is the off-loading procedure clear about the location and size of the liquid and vapor lines?
- When the dry disconnects are connected, are they locked in place by securing the arms in a closed position?
- Before opening the valves on both the vent and liquid sides, will a careful check for leaks be made?
- Are gas detectors installed at strategic points to sound an alarm if a leak occurs?
- At what pressure is the storage tank?

Note: If it is at a pressure that exceeds the vehicle safety system, the pressure relief valve will open and a vapor cloud will be released.

Pressure relief valves in North America are typically set to 25 psig (trailers), and 75 psig (rail cars). In Europe, the safety pressure setting is 400 kPa (4 bar) with initial opening at 300 kPa (3 bar) for both rail cars and Intermodal containers.

- After the transfer is initiated, is the operator required to stay within sight of the connections until the load is completely transferred? If a rail car is involved, how will it be monitored?

Note: This is required by U.S. law for tank trucks and rail cars.

- How will the operator know when the vehicle is empty so that the pump can be shut down as soon as it loses suction?
- If the liquid line will be blown clear prior to disconnection, how will the nitrogen be regulated to not exceed the pressure at which the vehicle's safety system begins to relieve? Are steps defined and followed if a blow-down is performed?

Note: Hoses should not be left hydraulically full.

- What procedure will be used to ensure all liquid and vapor return lines on the car and piping system are correctly blown clear, de-pressured, and blocked to secure the system and the delivery vehicle?

Note: Specially trained and licensed workers are required to accomplish the task of rail car and truck securement.

- When disconnection of the dry break fitting occurs, does the procedure require the use of appropriate protective gear?
- Will the hoses be secured to keep them clean and contamination-free for the next load?
- Will the operator ensure that the fall restraint, chocks, ground strap, and barricades are removed and that the placards are reversed and derail and warning signs are removed before releasing a rail car?
- Rail cars and European Intermodal containers also have top discharge lines. Establishing pump suction requires specific operating procedures. How will this be managed?

Note: The procedures must either utilize the pressure in the car upon arrival (North America 5 to 9 psi). In Europe, the overpressure in the cars and containers on the shipping point will be approximately 30 kPa (0.3 bar). Alternatively, the pressure can be provided by an inert gas (nitrogen) through the gas phase connection of the delivery vehicle to push the product out of the car to flood the pump suction.

Note: The customer should have a check valve in the inert gas line to avoid contamination and back flow into the inert gas system.

- What mechanism is in place that allows the operator to factor any learning experiences into the next off-loading experience – to continuously improve performance?

Storage and Equipment

The guidelines in this section of the Epichlorohydrin Product Stewardship Manual are general and should be used with information from tank and equipment manufacturers and professional engineering firms.

Materials of Construction

Carbon steel is satisfactory for the transport and storage of epichlorohydrin. Steel is used for storage tanks, lines, valves, fittings, and tank cars. Tank trucks are usually of stainless steel construction. If the material will be stored longer than 12 months, color may develop. In such cases, stainless steel tank construction should be considered.

Cast iron is not recommended for auxiliary equipment, such as pumps and valves, due to its brittleness.

Hazardous Materials

WARNING: The following materials can create varying degrees of hazard due to their incompatibility with epichlorohydrin.

Aluminum, Magnesium, Copper, Tin, Zinc, Lead, and Their Alloys

These metals should not be used in systems containing epichlorohydrin because of their potential to initiate a violent polymerization reaction. Similarly, alloys of these metals (such as bronzes and some brass compositions) should be avoided.

Catalysts

Epichlorohydrin may polymerize spontaneously and with explosive violence in the presence of catalysts such as acids, bases, and compounds having labile hydrogens (Lewis acids). Back-flow into storage vessels or lines must be prevented.

Bulk Handling Considerations

Some specific engineering design and procedural/operational considerations for off-loading and storage systems include:

- Spill containment for the storage tank and for vehicles that will be off-loaded

Note: A volume sufficient to hold the entire contents of the tank and vehicle is suggested.

- A nitrogen pad on the storage tank to ensure that the tank contents remain at less than 8 percent oxygen
- Isolation of the epichlorohydrin storage tank from storage areas containing materials reactive with epichlorohydrin
- Fire protection meeting local standards
- Over-pressure of the storage tank under normal and worst case conditions (usually fire)
- Overfill of the storage tank (e.g. level measurement, alarms and shut-down of unloading pump)
- Temperature measurement on the tank and pump
- Oxygen measurement, particularly with a new facility prior to first delivery
- Pump shut-down under abnormal conditions (e.g. deadhead, tank high level, low flow, high pump temperature, and lack of flow in vent back to vehicle)
- Exposure of workers and the environment during connection of the transfer

Note: Olin suggests using dedicated equipment permanently attached to transfer piping.

- Fittings to match those on the delivery vehicle
- Use of a customer-supplied pump with a closed-loop vapor return line. This is suggested over the use of nitrogen to pressure off the product with vapor abatement on the storage tank.
- If a closed-loop vapor return is not used, make sure that sufficient nitrogen is available and utilized to ensure that the oxygen level in the vehicle being off-loaded is permanently maintained at less than 8 percent

Note: Consider the allowed maximum pressure of the delivery vehicle. Olin prefers that delivery vehicles are returned with an overpressure of not more than 100 kPa (1.0 bar, ~15 psig).

- A sampling system and testing mechanism to confirm the product in the vehicle as epichlorohydrin (See Handling Instructions in “Health Hazards,” page 12)
- Blow-down of the unloading line prior to its disconnection from the delivery vehicle

Note: It is suggested that nitrogen be regulated to less than 100 kPa (1.0 bar, ~15 psig).

Storage and Equipment

- Prevention of back flow of any streams into the storage tank
- Plugging of line ends to prevent spills from an accidental valve opening (e.g. sampling and blow-down lines)
- Electrical grounding for storage tank, delivery vehicle, and off-loading system
- Safety shower and eye bath immediately accessible to the off-loading area, and tested prior to beginning the transfer
- Waste disposal practices to meet all regulations
- Tank and line labeling to indicate epichlorohydrin

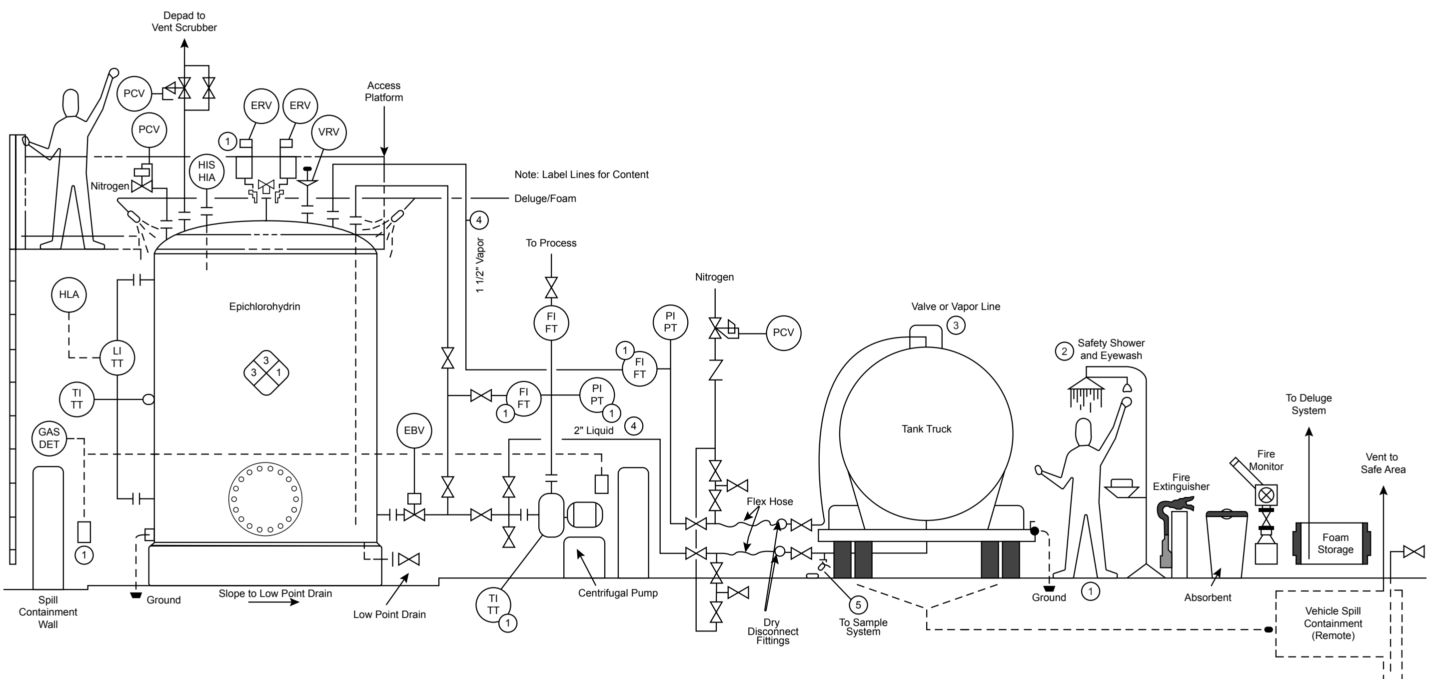
Note: The use of NFPA symbols (Health=3, Flammability=3, Reactivity=2) on the tank are suggested in North America.

- Flammable gas detection around the tank and other potential spill areas
- Process hazard analysis (see also "Emergency Preparedness," page 15)
- Emergency preparedness

Note: It is suggested that a Plant Emergency Plan be coordinated with the overall community emergency plan (See "Emergency Preparedness," page 15).

Also refer to Figures 9 and 10 for schematics of a typical bulk storage and tank truck off-loading system, and a typical rail car off-loading system.

Figure 9: Typical Bulk Storage and Tank Truck Bottom Off-Loading System for Epichlorohydrin



1. Pump to be turned off by:
   - High level in tank
   - Low pump discharge flow
   - High temperature
   - Low vent flow
   - Low pump discharge level
   - Loss of electrical ground
2. Safety shower must be quickly accessible from all product handling areas
3. For top off-loading configuration see rail car schematic, Figure 9
4. Vapor and liquid lines 2-inch and 3-inch respectively in Europe
5. See notes on page 20, Delivery Checklist

LEGEND

PCV = Pressure Control Valve

ERV = Emergency Relief Valve

VRV = Vacuum Relief Valve

HLS = High Level Switch

HLA = High Level Alarm

LI = Level Indicator

LT = Level Transmitter

TI = Temperature Indicator

TT = Temperature Transmitter

EBV = Emergency Block Valve

FI = Flow Indicator

FT = Flow Transmitter

PI = Pressure Indicator

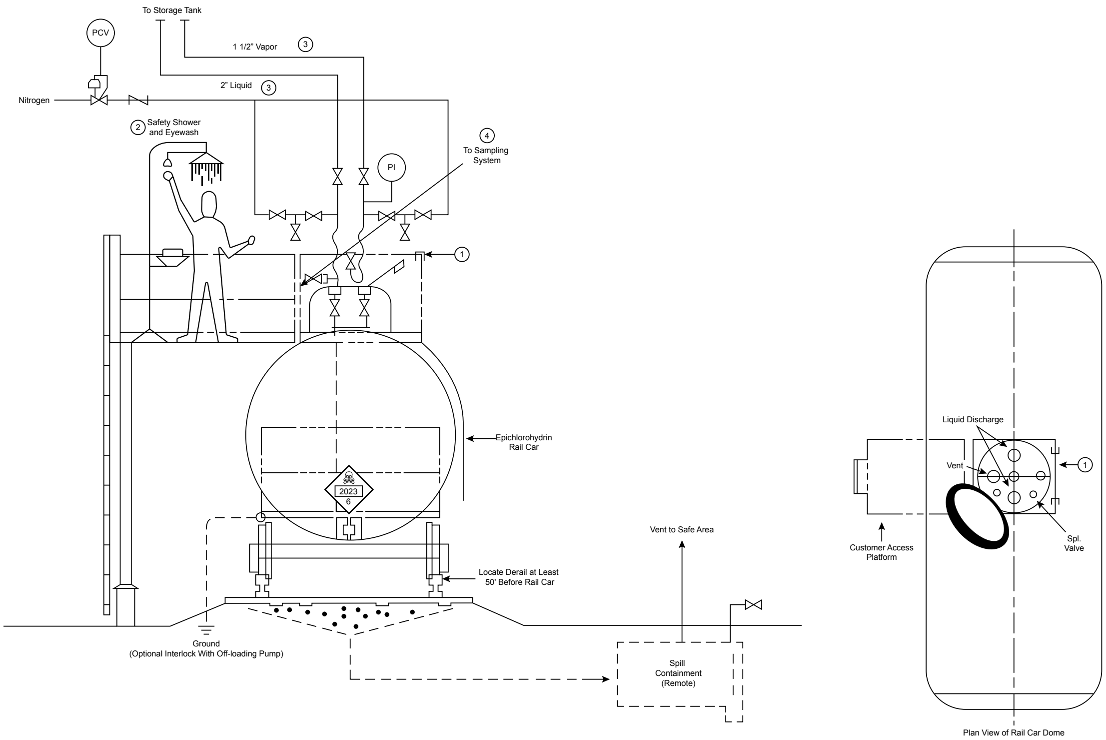
PT = Pressure Transmitter

GAS DET = Flammable Gas Detector

This schematic drawing is provided in good faith by Olin. However, as the delivery, storage, use and disposal conditions are not within its control, Olin does not guarantee results from the use of the schematic. The customer is advised to employ a qualified engineering service to design and build their storage and handling facility. Since any assistance furnished by Olin with reference to the safe delivery, storage, use and disposal of its products is provided without charge, Olin assumes no obligation or liability.

Storage and Equipment

Figure 10: Typical Rail Car Top Off-Loading System for Epichlorohydrin



1. Temporary handrail to be installed when working on the top of rail car

2. Additional safety shower required at ground level to be quickly accessible from all product handling areas

3. Vapor and liquid lines are 2-inch and 3-inch respectively in Europe

4. See notes on page 20, Delivery Checklist

Legend
PCV = Pressure Control Valve   PI = Pressure Indicator

This schematic drawing is provided in good faith by Olin. However, as the delivery, storage, use and disposal conditions are not within its control, Olin does not guarantee results from the use of the schematic. The customer is advised to employ a qualified engineering service to design and build their storage and handling facility. Since any assistance furnished by Olin with reference to the safe delivery, storage, use and disposal of its products is provided without charge, Olin assumes no obligation or liability.

Figure 11: Unloading a Bulk Tank Truck

An Olin customer demonstrates a typical hook-up of a bulk tank truck with dry disconnects

Figure 12: Typical Intermodal ISO Container

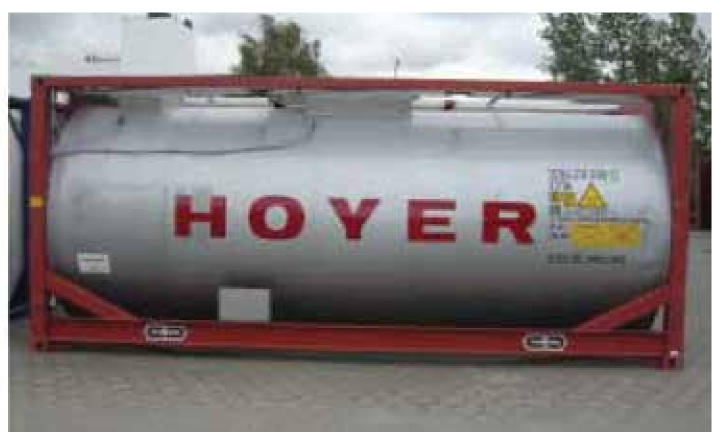


Photo courtesy of HOYER GmbH Hamburg, Germany, www.hoyer-group.com

Storage and Equipment

Tank Storage

The suggested storage tank for epichlorohydrin is an American Petroleum Industry (API) Type 620 tank that uses a nitrogen pad of 40-70 kPa (6-10 psi, 0.4-0.7 bar). American Society of Mechanical Engineers (ASME) code vessels with higher pressure ratings are also excellent choices.

A European design standard for tanks and vessels is EN 14015.

Note: The vapor pressure of epichlorohydrin is low enough that an atmospheric pressure tank (such as API Type 650 tank) could be used, but would probably not be the best choice due to the difficulty in maintaining a positive nitrogen pressure on the tank without venting epichlorohydrin vapors. Such a system would require special considerations to ensure that the vapors are appropriately scrubbed and did not pose an exposure potential for workers.

In any case, the tank should be designed, constructed, installed, and used in accordance with the appropriate national codes for epichlorohydrin storage. National Fire Protection Association (NFPA) codes are appropriate for North America. The tank should also meet all local codes and ordinances.

Carbon steel tanks are normally suitable for storage of epichlorohydrin. If the material will be stored for more than 12 months, however, stainless steel construction should be considered to prevent discoloration.

Storage tanks must be constructed to relieve excessive pressure in case of fire. This can be achieved through pressure relief valves or emergency relief vents of adequate capacity to relieve tank over-pressure and to prevent rupture.

Note: Open vents should not be used to avoid emissions to the atmosphere due to breathing of the tank.

Storage tanks must be diked or otherwise contained. Positive drainage to an impounding area that avoids exposure to personnel or equipment is suggested. Shell-to- shell separations of tanks should be based on loss prevention principles. The minimum distance from the tank shell to the dike wall should be set to prevent trajectories of escaping liquid (from possible leaks) from clearing the dike. Dikes should be designed with adequate volume to hold the maximum foreseeable spill with additional volume to contain deluge water and foam from extinguishing systems. Management of water during an emergency situation must be incorporated in the design.

Note: Careful design by a qualified engineering service is required to ensure an appropriately sized containment design to manage all potential emergencies.

Water spray rings around the tank are suggested to provide a water deluge when fighting fire (it also provides additional cooling for the tank in a fire situation). These same spray rings can be used to deliver foam by injecting the foaming agent into the water supply. Fire-fighting monitors around the storage facility should be considered as part of the design. Again, the fire protection system must be carefully designed by engineering experts who specialize in this service.

The storage tank should be equipped with a nitrogen gas padding system. An effective gas padding system can be created using a pressure control valve on the nitrogen supply line to maintain a minimum pressure (pad). It can also feature a maximum pressure (de-pad) pressure relief valve on top of the storage tank to prevent over-pressure. Such a system will not only provide a minimum positive pressure and protect against excessive pressure build-up, but also will conserve nitrogen. The nitrogen pad will preclude air from entering the system. Air contains moisture that can react with epichlorohydrin and/or its impurities to form other compounds which can be reactive or catalytic in nature.

Note: Tank vents should be handled in a manner that prevents personnel exposure and is acceptable from an emissions standpoint.

Olin suggests that vented material be handled by vapor return to the delivery vehicle. Tank breathing vapors are preferably incinerated in a well-designed incineration unit. Alternatively, the breathing vapors can be absorbed with a caustic scrubber, an absorption unit, or by condensation. Any of these systems will require a careful design by a qualified engineering service.

Mechanical pressure vacuum relief devices should also be provided to satisfy the relief requirements of codes and standards applicable to installation (e.g., NFPA in North America, EN standards in Europe).

Additional equipment should include adequate manholes or entrance passages that allow workers to clean or repair tanks, a bottom drain to completely empty tanks when necessary, and two independent level measurement devices.

Also, be sure that the tank and all metal piping and pumps are electrically grounded.

See Figures 9 and 10 for further instrumentation and control suggestions.

Because epichlorohydrin may homopolymerize spontaneously and with explosive force (100 kJ/mol, 24.3 kcal/mol at 25˚C/77˚F) in the presence of catalysts such as acids, bases, and compounds having labile hydrogens, it should be stored only in tanks that have been thoroughly cleaned and dried, e.g., buffed and steamed, water-washed, and dried with an inert gas, such as nitrogen (See section Tank Cleaning Procedures).

Note: Combining epichlorohydrin and water can form a particularly hazardous two-phase mixture (see "Properties and Uses," page 6, for solubility information). Over time, an exothermic reaction will start at the interface which can generate enough heat to create pressure build- up in the vessel. Such mixtures must be disposed of promptly (see "Emergency Preparedness," page 15, for disposal information).

Great care must be taken to prevent back flow or other inadvertent addition of reactive materials to the storage tanks. Prior to start-up, a process hazards analysis should be performed to identify flow, temperature, pressure, equipment failure, operating errors, or other conditions that could create an unexpected hazard (see "Emergency Preparedness," page 15).

Tank Cleaning Procedures

The following procedure to clean tanks containing epichlorohydrin is suggested.

Note: Tank cleaning will require personnel to enter the epichlorohydrin storage vessel. To ensure this is done safely, a detailed vessel entry procedure that includes the testing of the environment in the tank should be developed by qualified personnel. The procedure should be used and signed by the responsible people, including the operator and trades person.

1. Use a pump to remove the epichlorohydrin from the tank until the pump loses prime
2. Blind or remove all process piping from the tank to avoid accidental flows into the tank during the clean-up or tank entry procedures
3. Fill the tank at least half way with water to remove any liquid pockets of epichlorohydrin. If the tank is too large or disposal of water is a problem, this step may be omitted if the following Step 4 is performed
4. Water-wash for at least 8 hours using some form of multi-directional spray washing nozzle (e.g., the type used to wash tank trucks or cars). Alternatively a 10 percent Sodium hydroxide solution can be used for about 1 hour.

Note: This step is essential to tank cleaning; it greatly minimizes the amount of epichlorohydrin that could vent out in the following steps.

5. The remaining steps of the cleaning procedure are dependent upon the type of lining and exterior paint on the tank, and the amount of deposits in the tank itself. These steps are categorized as low-, medium-, and high-temperature cleaning procedures. Follow Steps 1-4 above, then proceed with the steps described in the low-, medium-, or high-temperature categories.

Note: It is very important to use the following cleaning procedures regarding proper temperature limits on linings, exterior paints, and insulation, since most manufacturer's guidelines do not have large safety factors. Linings and exterior paints are very easily damaged by heat, and are expensive to repair.

Note: All water and epichlorohydrin mixtures must be contained and disposed of as required by regulations (see "Waste Disposal," page 16).

Low-Temperature Cleaning

This type of procedure should be used for any tank that is lined, insulated, or painted with a material that is not capable of withstanding above-ambient temperatures.

5a. Continue washing with the multi-directional spray nozzle set-up for an additional 12-16 hours. Open all drains on the tank.

5b. Connect an air-moving device capable of quickly turning over the air volume in the tank

5c. Test the tank environment for flammability, toxicity, and oxygen content. See under tank entry below.

5d. If the air test results show that it is not acceptable to enter, continue to wash the tank until acceptable limits are reached

Medium-Temperature Cleaning

This type of procedure is appropriate for tanks that are lined, insulated, or painted with a material capable of withstanding boiling water up to 100˚C (212˚F), but not direct steaming.

5a. Open a vent valve at the top of the tank and fill the tank 80 percent with water

5b. Connect a steam hose to the bottom of the tank and introduce steam. Raise the water temperature to boiling, then boil the water for 6 to 8 hours. Be careful not to overboil, causing water to exit the vent valve.

5c. Drain the water and purge the tank to ambient temperature with an air-moving device

5d. Test the tank environment for safe levels of flammability, toxicity, and oxygen. See Tank/Vessel Entry, below.

5e. Repeat the boiling procedure if the air tests are unacceptable. Continue until acceptable limits are reached.

High-Temperature Cleaning

Use this procedure for any tank that is lined, insulated, or painted with a material capable of withstanding temperatures up to 250˚C (482˚F).

5a. Open the vent and drain valves on the tank

5b. Connect a low pressure (240 kPa, 2.4 bar, ~35 psig or less) steam hose to the tank and flow steam into it, making sure that the tank does not over-pressure

5c. Increase the tank temperature to 95˚C (203˚F) for 2 to 4 hours, or until no detectable epichlorohydrin is remaining

5d. Turn off the steam, connect an air-moving device, and cool the tank down to ambient temperature

5e. Test the tank environment for acceptable levels of flammability, toxicity, and oxygen content as outlined in the tank entry section below

5f. If any tests show that it is unacceptable to enter, the tank should be further steamed until acceptable limits are reached

Tank/Vessel Entry

A written tank entry procedure should be in place. This procedure should regulate which tests have to be done prior to the approval of tank entry by a responsible person. Required tests are oxygen content, flammability, detectable epichlorohydrin and electrical safety. Suggested additional tests are temperature (especially after steaming). The procedure should further regulate who gives the final approval for tank entry. Persons entering tanks should wear appropriate personal protective gear.

Table 9: Guidelines for Acceptable Tank Entry

Conditions	Acceptable Levels
Flammability	Essentially Zero
Toxicity	Less than 0.5 ppm epichlorohydrin in vapor space
Oxygen Content	19.5 – 23.5 percent
Temperature	Less than 40˚C (104˚F)

Note: If the tank contained other compounds, the environment should be tested for safe levels of those compounds, too. Check with the relevant manufacturer for acceptable levels of entry.

Storage and Equipment

Recommissioning

Before filling a tank with epichlorohydrin, follow these steps:

1. Pad and de-pad with nitrogen until the measured oxygen content is 8 percent or less
2. The tank must be dry. This can be assured by making a dew point determination on a representative sample of a nitrogen purge flow from the tank. A dew point of less than -40˚C (-40˚F), as measured by a dew-point apparatus, is used at Olin as the acceptable level of dryness.
3. Ensure that all safety and other systems are reinstalled and tested to verify correct operation

Note: Nitrogen Hazard! A number of fatalities have recently been caused by persons entering into areas and equipment with oxygen-deficient atmosphere. If a person enters an atmosphere of nitrogen, he or she can lose consciousness without any warning symptoms in as little as 20 seconds. Death can follow in 3-4 minutes. A person falls as if struck by a blow on the head. All personnel should know that one deep breath of 100 percent nitrogen will be fatal. Breathing is stimulated and controlled (cerebellum) by carbon dioxide present in the lungs. 100 percent nitrogen will displace carbon dioxide completely. In the absence of a carbon dioxide signal to the brain, breathing stops. Personnel should not work in or enter atmospheres with oxygen concentration below 19.5 percent or above 23.5 percent, unless equipped with a self-contained breathing apparatus or breathing air mask. This is also true of rescue personnel who can be overcome by the same oxygen-deficient atmosphere as the initial victim.

Equipment Specifications

Examples below may be specific to North America. Check with your country standards or involve a local engineering company.

Lines, valves, pumps, and fittings can be of ordinary carbon steel or ductile iron.

Note: Do not use cast iron due to its brittleness. Also avoid aluminum, magnesium, copper, tin, zinc, lead, and their alloys due to their potential reaction with epichlorohydrin.

Spiral-wound gaskets with polytetrafluoroethylene (PTFE) filler, flexible graphite filler, or filled PTFE gasket (e.g. Gylon 3510 or Durlon 9000) have been used satisfactorily. Centrifugal pumps equipped with dual mechanical seals or magnetically-driven (seal-less) generally provide good protection for workers.

When mechanically sealed pumps are used a combustible gas detector (ex-detector) is recommended. The gas detector should be located near each epichlorohydrin pump to detect any pump seal leaks.

The number of flanged connections should be kept at a minimum to minimize fugitive emissions. Exterior painting is also suggested.

Threaded connections should be kept to an absolute minimum and no steam tracing should be used on piping.

Table 10 provides guidelines for tank piping and other equipment used for epichlorohydrin storage and transfer systems. For specific information about tank hardware, consult with a professional engineering firm and, if desired, discuss engineering specifications with Olin. Talk to your Olin representative or contact your nearest Olin location.

Table 10: Equipment Specifications

Olin suggests stainless steel (316 SS) equipment be used to store and handle epichlorohydrin. Carbon steel is also a suitable construction material.

Conditions	Acceptable Levels
Gaskets	Spiral-wound, 304 stainless steel or Monel winding, PTFE or flexible graphite filler, 0.175" thick, API-601 for ASME/ANSI B16.5 flanges, carbon steel centering ring, no inner ring Flat ring: filled PTFE, 1/16" thick, Gylon 3510, Blueguard 3700 or Durlon 9000
Dry Break Valves	e.g. Civacon for the 1 1/2" and 2" female couplers and male adapters respectively Note: dry-break couplings are currently used only in North America
"O" Rings	PTFE, EPDM, EPR, Viton, Kalrez 4079
"V" Rings	PTFE
Pumps	Seal-less pump, preferably magnetic drive used in clean service Mechanical seal pumps (centrifugal), double seal using non-toxic purge Pump body duplex stainless steel; CD4M (cast) or 2200 series (plate) steel, ductile iron or 316 stainless steel Volute case gasket, glass-filled PTFE or PTFE envelope
Seal Hard Faces	Carbon/tungsten
Hoses	Polypropylene lined with inner wire construction 316 SS. (e.g. Wilcox type 4091 or equivalent) Polypropylene with PVC linings and galvanized outer wire (e.g. Chemoflex 0416-PG)
Tank Linings	Unlined steel acceptable for most applications Contact your Olin representative for linings information
Electrical Classification	Minimum-U.S. Class I, Division II, Group C Maximum-Class I, Division I, Group C Electrical motors should have individual high temperature protection All equipment should be grounded

Note: The customer is advised to employ a qualified engineering service to design and build its storage and handling facility. Since any assistance furnished by Olin with reference to the safe delivery, storage, use and disposal of its products, is provided without charge, Olin assumes no obligation or liability.

Analytical Methods

Please consult your Olin representative for analytical methods for testing the quality of epichlorohydrin, analyzing trace amounts of epichlorohydrin in water, and monitoring epichlorohydrin in air.

The Olin assay method for epichlorohydrin is applicable to epichlorohydrin having 99.0 percent or greater purity. Impurities are determined and the sum of those concentrations is subtracted from 100 percent. The complete Olin analytical method is available on request.

Other Safety Considerations Include:

- Use of appropriate respiratory, hand, body, and eye protection should be determined according to the exposure potential of each operation
- Carbon disulfide and other reagents may pose health hazards. Follow the safety precautions suggested by the reagent supplier.
- Each analyst should be acquainted with the potential hazards of the reagents, products, and solvents before commencing laboratory work. Sources of information include: SDS, technical and product literature, and other related data. Safety information on non-Olin products should be requested from the relevant supplier. Disposal of reagents, reactants, and solvents must be in compliance with applicable government requirements within your country.

Other Useful Methods

The following sources are useful methods for testing epichlorohydrin. They are available from the ASTM International, 1916 Race Street, Philadelphia, Pennsylvania 19103, USA.

- "Water in Liquid Petroleum Products by Karl Fischer Reagent," Designation ASTM E-203
- "Color of Halogenated Organic Solvents and Their Admixtures (Platinum-Cobalt Scale)," Designation ASTM D-1209

Regulatory Requirements

Details to the country-specific regulatory requirements are provided in section 15 of the country-specific SDS. Olin recommends you review the SDS prior to any work.

Chemical Inventory Listing

Epichlorohydrin (CAS Number 106-89-9) is listed in the following national chemical inventories:

Table 11: Chemical Inventory Listing

National Chemical Inventory	Chemical Substance Inventory	Inventory Number
Australia	AICS	106-89-8
Canada	DSL	106-89-8
China	IECSC	106-89-8
European Community	EINECS 67/548/EEC Annex I	203-439-8 603-026-00-6
India	List of Hazardous Chemicals	106-89-8
Japan	ENCS/ISHL	(2)-275
Korea	KECI	KE-05647
New Zealand	NZIoC	106-89-8
Philippines	PICCS	106-89-8
Switzerland	Giftliste 1	G-1614
Taiwan	TCSI	106-89-8
USA	TSCA	106-89-8

Legend
- AICS = Australian Inventory of Chemical Substances
- DSL = Domestic Substances List
- EINECS = European Inventory Existing Commercial Chemical Substances
- ENCS = Inventory of Existing and New Chemical Substances
- ISHL = Industrial Safety & Health Law Inventory
- KECI = Korean Existing Chemicals Inventory
- PICCS = Philippine Inventory of Chemicals and Chemical Substances
- SEPA = State Environmental Protection Agency China Chemical Inventory
- TSCA = Toxic Substances Control Act Chemical Substances Inventory

International Transportation Requirements

Section 14 of the country-specific SDS provides details about the transportation restrictions and labeling requirements. The details provided below reflect the international transportation classification status for the year 2016.

Road & Rail

Proper shipping name	EPICHLOROHYDRIN
Truck/Rail ADR/RID	6.1
Label	6.1+3
Classification Code	TF1
Packing Group	II
Kemler Code	63
UN Number	2023
Tremcard Number CEFIC	61S2023

Sea

Proper shipping name	EPICHLOROHYDRIN
Sea - IMO/IMDG Class	6.1
UN Number	2023
Label	6.1+3
Packing Group	II
EMS	6.101
Marine Pollutant (Y/N)	Y

Air

Proper shipping name	EPICHLOROHYDRIN
Air - ICAO/IATA Class	6.1
UN Number	2023
Label	TOX+FL
Sub Class	3
Packing Group	II
Pack Instruction (Passenger)	609
Pack Instruction (Cargo)	611

Remarks: Sample shipment not allowed by mail.

Olin Product Stewardship

Olin Product Stewardship

Olin encourages its customers and potential users of Olin products to review their applications of such products from the standpoint of human health and environmental quality. To help ensure that Olin products are not used in ways for which they are not intended or tested, Olin personnel will assist customers in dealing with environmental and product safety considerations. An Olin sales representative can arrange the proper contacts. Olin product literature, including Safety Data Sheets (SDS), should be consulted prior to use of Olin products. These may be obtained by contacting the Olin Customer Care at 1-844-238-3445 in the U.S. (See back page for additional contact information).

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Toll free service not available in all countries

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