Table of Contents

Contact Information & Legal Notice
   Emergency Contact Information .................................................. 1
   Legal Notice ................................................................................. 1

General Information
   Product Identification ................................................................. 2
   Applications ................................................................................. 2
   Instability and Reactivity Hazards ............................................... 3
   Physical Properties ....................................................................... 4
   Acronyms and Abbreviations ....................................................... 9

First Aid
   Eye Exposure .............................................................................. 11
   Skin Exposure ............................................................................. 11
   Inhalation .................................................................................... 12
   Ingestion ..................................................................................... 12

Hazard Assessment
   Acute Effects of Overexposure .................................................... 13
   Repeated Exposures .................................................................... 13
   Chronic Effects of Overexposure .................................................. 14
      Carcinogenicity ........................................................................ 14
      Reproductive and Developmental Toxicity ............................... 14
      Genetic Toxicity ....................................................................... 14
   Exposure Limits .......................................................................... 15

Personal Protective Equipment
   Eye Protection ............................................................................ 16
   Respiratory Protection ................................................................ 17
   General Protective Clothing ....................................................... 17
   Impervious Gloves and Clothing ............................................... 18
   Protective Equipment Training ................................................... 19

Sampling Equipment
   On-stream Methods .................................................................... 20
   Manual Methods ......................................................................... 20
      Safety-Coated Glass Bottle Method ......................................... 20
      Stainless Steel Cylinder Method ............................................ 20
   Other Safety Considerations ...................................................... 20
# Table of Contents

**Emergency Planning**
- Plan Development .................................................. 22
- Fire Hazards ......................................................... 23
- Fire Prevention and Protection ................................. 23
- Static Electricity ..................................................... 24
- Fire and Explosion ................................................. 25
  - Fire Fighting ...................................................... 25
  - Fire Suppression .................................................. 26

**Environmental**
- Spills and Leaks ..................................................... 27
- Waste Disposal ....................................................... 28
- Absorbents ............................................................. 29

**Bulk Handling**
- General Design Considerations ............................... 30
- Vessels ................................................................ 32
- Piping .................................................................. 34
- Valves .................................................................. 34
- Pumps .................................................................. 35

**Tank Cleaning & Equipment Repair**
- Work Preparation ..................................................... 36
- Control of Hazardous Energy .................................. 36
- Confined Space Entry ............................................. 36
- Equipment Cleanout and Recommissioning Vessels .... 36
- Maintenance and Inspection ................................... 37

**Delivery & Transfer**
- Considerations for Delivery ................................... 38
- Rail Cars ................................................................. 43
  - Considerations for Unloading Rail Cars .................. 46
  - General Guidelines for Unloading Rail Cars .......... 47
- Tank Trucks ............................................................. 48
  - Consideration for Unloading Tank Trucks ............... 48
  - General Procedures for Unloading Tank Trucks .... 50
- ISO Containers ......................................................... 51
  - ISO Tank Shipments and Unloading Guidelines ...... 51
  - Material and/or Container Return Guidelines ....... 51
# Table of Contents

Security ....................................................... 53
Regulations .................................................... 54
References ..................................................... 56

Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Propylene Oxide Physical Properties</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Propylene Oxide Density as a Function of Temperature</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Propylene Oxide Vapor Pressure as a Function of Temperature</td>
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Figures

<table>
<thead>
<tr>
<th>Figure</th>
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</tr>
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<tbody>
<tr>
<td>1</td>
<td>Flammability Diagram for Propylene Oxide</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Flammability Triangle for Propylene Oxide</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Typical Pressure Storage Tank Configuration</td>
<td>31</td>
</tr>
<tr>
<td>4</td>
<td>Typical Tank Car Dome Configuration</td>
<td>42</td>
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<tr>
<td>5</td>
<td>Typical Tank Car Configuration</td>
<td>44</td>
</tr>
<tr>
<td>6</td>
<td>Typical Tank Car Unloading System Configuration</td>
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<td>Typical IMO Tank Configuration</td>
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Emergency Contact Information

24 hour Emergency Hotlines
IN CASE OF TRANSPORTATION
EMERGENCY CALL:
CHEMTREC 1-800-424-9300
International (call collect) 703-527-3887

Company Contact Information:
The Dow Chemical Company
(Local) 989-636-4400
(Toll-free) 1-800-258-2436
www.dow.com

Huntsman LLC
(Local) 713-727-0831
(Toll-free) 1-800-328-8501
www.huntsman.com

Lyondell Chemical Company
(Toll-free) 1-800-245-4532
www.lyondell.com

Legal Notice

This manual is provided through the combined efforts of The Dow Chemical Company, Huntsman, and Lyondell. The Propylene Oxide Storage & Handling Guidelines Manual is intended to provide general information to persons who manufacture, use, or handle propylene oxide. The Manual is not intended to be a “how-to” manual, nor is it a prescriptive guide.

Individual companies may need to vary approaches to particular practices described in the Manual based on specific factual circumstances, the practicality and effectiveness of particular actions, or economic and technological feasibility.

The Manual is not intended to be a substitute for in-depth training or specific requirements, nor is it intended to define or create legal rights or other obligations. All persons involved in manufacturing, using, or handling propylene oxide have an independent obligation to ascertain that their actions are in compliance with current federal, state, and local laws and regulations and should consult legal counsel concerning such matters.

Neither the contributing companies, nor any of their employees, subcontractors, consultants, or other assigns, makes any warranty or representation, either expressed or implied, with respect to the accuracy or completeness of the information contained in the Manual. The contributing companies assume no liability or responsibility for any use, or the results of such use, of any information, procedure, conclusion, opinion, product, or process disclosed in this Manual.

Propylene oxide users are encouraged to consult Dow’s current Material Safety Data Sheet (MSDS) for specific guidance and updates on safe handling and use. Should you have specific questions about information contained in the Manual, you may contact the identified member companies for further information.
General Information

Product Information

- **Formula**: \( \text{C}_2\text{H}_4\text{O} \)
- **CAS Number**: 75–56–9
- **EINECS Number**: 200-879-2
- **IUPAC Name**: 2–Methyl Oxirane
- **Chemical Family**: Alkylene Oxides

**Common Names**
- Propylene oxide
- 1,2–Propyleneoxide
- Alkyl Epoxide
- 1,2–Epoxypropane
- Propene epoxide
- Propene oxide
- Methyl Ethylene Oxide

Applications

Propylene oxide is a versatile chemical intermediate used in a wide range of industrial and commercial products and is among the top 50 chemicals, by volume, produced in the world. Propylene oxide is a member of a group of compounds known as alkylene oxides. Alkylene oxides react readily with compounds containing an active hydrogen atom, such as alcohols, amines, and acids. These reactions are generally known as alkoxylation and are chemical routes to many important products, such as specialty surfactants, solvents, food additives, and oil field chemicals.

The polyurethane industry is the largest consumer of propylene oxide. It uses polyether polyols made by reacting propylene oxide alone or in combination with other alkylene oxides. The most common initiators are polyols or polyamines such as glycerin, glycols, pentaerythritol, ethylenediamine, toluenediamine, sucrose, sorbitol, trialkanol amines, and trimethylolpropane. Polyether polyols are reacted with various diisocyanates to form polyurethane foams and resins.

The second largest use of propylene oxide is the production of propylene glycol and lesser amounts of co-produced dipropylene glycol and higher propylene glycols. Propylene glycol is one of the most widely used synthetic chemicals, finding its way into such diverse applications as the manufacture of thermoset polyesters for building boats, home construction components, additives for human and animal foods, and pharmaceutical excipients. It is also a primary ingredient in cosmetics and laundry detergents.

Propylene oxide is also used to manufacture functional fluids by reaction of propylene oxide or mixtures of propylene oxide and ethylene oxide with glycols, glycerin, alcohols, and phenols. The types of functional fluids produced include heat transfer fluids, hydraulic fluids, and lubricants.

Other propylene oxide derivatives include block copolymers of propylene oxide and ethylene oxide, which have been found to be efficient and versatile surfactants. Propylene oxide-based surfactants can also be produced by the propoxylation of various alcohols. The water solubility of propylene glycols with molecular weight less than 800 makes propylene oxide especially useful in these applications.
Propylene oxide is also used to propoxylate or modify carbohydrates (starches). Propoxylated carbohydrates, or starches, are used in a variety of applications in the construction, paint, food, and pharmaceutical industries.

Propylene oxide is also used as a reactant to produce alkanol amines from ammonia or amines and as an intermediate in the production of allyl alcohol.

Instability and Reactivity Hazards

Propylene oxide is a stable material that will not decompose under normal conditions of temperature and pressure.

Propylene oxide may react vigorously with oxidizing materials, anhydrous metal halides, acids, bases, clay-based adsorbent materials, and peroxides. Propylene oxide mixed with ammonium hydroxide, chlorosulfonic acid, hydrochloric acid, hydrofluoric acid, nitric acid, oleum (fuming sulfuric acid), or sulfuric acid causes violent reactions. Propylene oxide reacts slowly in neutral water. However, the presence of acids or bases in water will catalyze the hydrolysis of propylene oxide, and a highly exothermic reaction may occur.
### Physical Properties

**Table 1  Propylene Oxide Physical Properties**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical State</td>
<td>Liquid</td>
</tr>
<tr>
<td>Color</td>
<td>Colorless</td>
</tr>
<tr>
<td>Molecular Weight</td>
<td>58.08 g/mol</td>
</tr>
<tr>
<td>Boiling Point, 101.3 kPa</td>
<td>34.5˚C (94.1˚F)</td>
</tr>
<tr>
<td>Freezing Point</td>
<td>-111.93˚C (-169.47˚C)</td>
</tr>
<tr>
<td>Density 25˚C (77˚F)</td>
<td>0.823 g/cm³ (6.87 lb/gal)</td>
</tr>
<tr>
<td>Density of Saturated Liquid</td>
<td>See Table 2</td>
</tr>
<tr>
<td>Vapor Density (Air=1.0)</td>
<td>2.0</td>
</tr>
<tr>
<td>Vapor Pressure</td>
<td>See Table 3</td>
</tr>
<tr>
<td>Index of Refraction</td>
<td></td>
</tr>
<tr>
<td>@ 25˚C (77˚F)</td>
<td>1.3632</td>
</tr>
<tr>
<td>@ 20˚C (68˚F)</td>
<td>1.3670</td>
</tr>
<tr>
<td>Coefficient of Cubical Expansion @ 20˚C (68˚F)</td>
<td>0.00151/˚C (0.00084/˚F)</td>
</tr>
<tr>
<td>Critical Temperature</td>
<td>209.1˚C (408.4˚F)</td>
</tr>
<tr>
<td>Critical Pressure</td>
<td>4.92 MPa</td>
</tr>
<tr>
<td>Critical Volume</td>
<td>3.2025 cm³/g (0.513 ft³/lb)</td>
</tr>
<tr>
<td>Critical Compression</td>
<td>0.228</td>
</tr>
<tr>
<td>Acentric Factor</td>
<td>0.2683</td>
</tr>
<tr>
<td>Heat of Combustion, Liquid @ 25˚C (77˚F)</td>
<td>-426.745 kcal/mol</td>
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<tr>
<td>Heat of Formation, Vapor @ 25˚C (77˚F)</td>
<td>-22.395 kcal/mol</td>
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<td>Heat of Formation, Liquid @ 25˚C (77˚F)</td>
<td>-29.302 kcal/mol</td>
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<td>Heat of Fusion @ -112˚C (-170˚F)</td>
<td>1560.9 cal/mol (2809.6 BTU/lbmol)</td>
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<tr>
<td>Flash Point, TAG-Closed Cup</td>
<td>-37.2˚C (-35˚F)</td>
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<tr>
<td>Autoignition Temperature</td>
<td>449˚C (840˚F)</td>
</tr>
<tr>
<td>Upper Explosion Limit</td>
<td>42 vol%</td>
</tr>
<tr>
<td>Lower Explosion Limit</td>
<td>1.6 vol%</td>
</tr>
<tr>
<td>Solubility @ 20˚C (68˚F)</td>
<td>39.5% PO in Water, 12.5% Water in PO</td>
</tr>
<tr>
<td>Alcohol: &gt;&gt; Ether: ==</td>
<td></td>
</tr>
<tr>
<td>Saturation Concentration in Air @ 25˚C (77˚F)</td>
<td>82.6 wt% (70.32 mol%)</td>
</tr>
<tr>
<td>Dipole Moment</td>
<td>6.70 x 10⁻³ C·m</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>2.4 x 10⁻⁸ mhos/cm</td>
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<tr>
<td>Specific Heat, 0˚C (32˚F)</td>
<td>2.0 J/(g·˚C) (0.48 BTU/lb/˚F)</td>
</tr>
<tr>
<td>Viscosity, 25˚C (77˚F)</td>
<td>0.29 centipoise (mPa·s)</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>See Table 2</td>
</tr>
</tbody>
</table>

(Rowley et al., 2004)
### Physical Properties

#### Table 2: Propylene Oxide Density as a Function of Temperature

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Temperature (°F)</th>
<th>Grams per Cubic cm</th>
<th>Lb. per U.S. Gallon</th>
<th>Specific Gravity to 60°C (140°F)</th>
<th>Temperature (°C)</th>
<th>Temperature (°F)</th>
<th>Grams per Cubic cm</th>
<th>Lb. per U.S. Gallon</th>
<th>Specific Gravity to 60°C (140°F)</th>
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</thead>
<tbody>
<tr>
<td>4.4</td>
<td>40</td>
<td>0.8488</td>
<td>7.083</td>
<td>1.0164</td>
<td>21.7</td>
<td>71</td>
<td>0.8275</td>
<td>6.905</td>
<td>0.9908</td>
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<td>5.0</td>
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<td>1.0156</td>
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<td>72</td>
<td>0.8268</td>
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<td>0.9900</td>
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<td>5.6</td>
<td>42</td>
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<td>73</td>
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<td>43</td>
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<td>1.0140</td>
<td>23.3</td>
<td>74</td>
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<td>0.9883</td>
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<td>6.7</td>
<td>44</td>
<td>0.8461</td>
<td>7.060</td>
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(Rowley et al., 2004)
## Physical Properties

### Table 3  Propylene Oxide Vapor Pressure as a Function of Temperature

<table>
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<tr>
<th>Temperature °C</th>
<th>°F</th>
<th>Vapor Pressure mm Hg</th>
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<td>34.00</td>
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<td>14.45</td>
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</tr>
</tbody>
</table>

(From [Rowley et al., 2004](#))

### Key

- **psia**: pounds per square inch absolute
- **psig**: pounds per square inch gauge

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General Information
General Information

Test Methods

ASTM E 2079  Limiting Oxygen (Oxidant) Concentration in Gases and Vapors
ASTM E 681  Concentration Limits of Flammability of Chemicals (Vapors and Gases)

Test Conditions

5-liter stainless sphere
100°C (212°F) at 1 atmosphere
Figure 2  Flammability Triangle for Propylene Oxide

Larry Britton, Neolytica, February 2005
All values are in percent mole.
## Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACGIH</td>
<td>American Conference of Governmental Industrial Hygienists</td>
</tr>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>API</td>
<td>American Petroleum Institute</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing Materials</td>
</tr>
<tr>
<td>CAER</td>
<td>Community Awareness and Emergency Response</td>
</tr>
<tr>
<td>CAS</td>
<td>Chemical Abstracts Service</td>
</tr>
<tr>
<td>CEFIC</td>
<td>Conseil Européen des Federations de l’Industrie Chimique (European Chemical Industry Association)</td>
</tr>
<tr>
<td>CERCLA</td>
<td>Comprehensive Environmental Response, Compensation and Liability Act (U.S.)</td>
</tr>
<tr>
<td>CFR</td>
<td>Code of Federal Regulations (U.S.)</td>
</tr>
<tr>
<td>DIPPR</td>
<td>Design Institute for Physical Property Data</td>
</tr>
<tr>
<td>DOT</td>
<td>Department of Transportation (U.S.)</td>
</tr>
<tr>
<td>EINECS</td>
<td>European Inventory of Existing Commercial Chemical Substances</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency (U.S.)</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>HAZWOPER</td>
<td>Hazardous Waste Operations and Emergency Response</td>
</tr>
<tr>
<td>IARC</td>
<td>International Agency for Research on Cancer (United Nations World Health Organization)</td>
</tr>
<tr>
<td>ID</td>
<td>Inside diameter</td>
</tr>
<tr>
<td>IMO</td>
<td>International Maritime Organization</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Organization</td>
</tr>
<tr>
<td>LFL</td>
<td>Lower Flammability Limit</td>
</tr>
<tr>
<td>LOC</td>
<td>Lower Oxygen Content</td>
</tr>
<tr>
<td>mg/m³</td>
<td>milligram per cubic meter</td>
</tr>
<tr>
<td>MSDS</td>
<td>Material Safety Data Sheet</td>
</tr>
<tr>
<td>MSHA</td>
<td>Mine Safety and Health Administration (U.S.)</td>
</tr>
<tr>
<td>NEC</td>
<td>National Electrical Code (U.S.)</td>
</tr>
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<td>NFPA</td>
<td>National Fire Protection Association</td>
</tr>
<tr>
<td>NIOSH</td>
<td>National Institute for Occupational Safety and Health (U.S.)</td>
</tr>
<tr>
<td>NTP</td>
<td>National Toxicology Program (U.S.)</td>
</tr>
<tr>
<td>OSHA</td>
<td>Occupational Safety and Health Administration (U.S.)</td>
</tr>
<tr>
<td>PEL</td>
<td>Permissible Exposure Limit</td>
</tr>
<tr>
<td>POTW</td>
<td>Publicly Owned Treatment Works</td>
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## Acronyms and Abbreviations (con’t)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>PPE</td>
<td>Personal Protective Equipment</td>
</tr>
<tr>
<td>ppm</td>
<td>parts per million</td>
</tr>
<tr>
<td>psi</td>
<td>pounds per square inch</td>
</tr>
<tr>
<td>psia</td>
<td>pounds per square inch absolute</td>
</tr>
<tr>
<td>psig</td>
<td>pounds per square inch gauge</td>
</tr>
<tr>
<td>PSV</td>
<td>Pressure Safety Valves</td>
</tr>
<tr>
<td>PTFE</td>
<td>Polytetrafluoroethylene</td>
</tr>
<tr>
<td>RCRA</td>
<td>Resource Conservation and Recovery Act (U.S.)</td>
</tr>
<tr>
<td>RMP</td>
<td>Risk Management Plan</td>
</tr>
<tr>
<td>RoC</td>
<td>Report on Carcinogens (U.S.)</td>
</tr>
<tr>
<td>RQ</td>
<td>Reportable Quantity</td>
</tr>
<tr>
<td>SARA</td>
<td>Superfund Amendments and Reauthorization Act (U.S.)</td>
</tr>
<tr>
<td>SCBA</td>
<td>Self-contained breathing apparatus</td>
</tr>
<tr>
<td>STEL</td>
<td>Short Term Exposure Limit</td>
</tr>
<tr>
<td>TLV</td>
<td>Threshold Limit Value</td>
</tr>
<tr>
<td>TSCA</td>
<td>Toxic Substances Control Act (U.S.)</td>
</tr>
<tr>
<td>TWA</td>
<td>Time-weighted average</td>
</tr>
<tr>
<td>UFL</td>
<td>Upper Flammability Limit</td>
</tr>
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</table>
First Aid

The information in this section is general in nature and should be used in conjunction with Dow’s current propylene oxide Material Safety Data Sheet (MSDS). The MSDS should be reviewed prior to working with propylene oxide.

Personnel involved in handling propylene oxide should be trained about the specific hazards of this chemical and about decontamination procedures in the event of overexposure.

Responders providing assistance to an overexposed person should be cautious not to contaminate themselves by touching the person’s clothing unless wearing appropriate protective apparel. The victim’s clothing should be removed to minimize continued skin contact, and to prevent continued off-gassing of propylene oxide during transport to an emergency care facility. Emergency transport services should be equipped to provide continual flushing of the skin and eyes with water, especially when the victim is complaining of burning or irritation.

Eye Exposure
Propylene oxide may cause severe eye irritation and possibly corneal burns. High levels of propylene oxide vapors may also irritate the eyes. If propylene oxide gets into the eyes, immediately wash them with clean water for at least 30 minutes while periodically lifting the lower and upper eyelids to enhance flushing. Remove contact lenses after the first 5 minutes and continue washing. Continue washing and have the exposed person attended to by a physician immediately. Vehicles used to transport the exposed person must be equipped with facilities to continue washing during transport.

Skin Exposure
Propylene oxide generally does not cause adverse effects to the skin if it can freely evaporate. Confined contact or contact with propylene oxide in aqueous solutions can cause damage ranging from irritation to severe burns. If skin is exposed, all clothing covering the affected area should be removed and the area washed with flowing water or a shower for at least 15 minutes. Remove watches, rings, or anything else that could hold propylene oxide in contact with the skin. Put on a complete change of clothing. Do not wear contaminated clothing until it has been properly cleaned. Remove and discard contaminated items such as leather belts, wallets, and shoes. Leather cannot be adequately decontaminated and can increase localized burn potential by holding the propylene oxide against the skin. Also, discard rubber footwear if propylene oxide was inside the shoe or boot. Discarded clothing, accessories, and/or footwear should be properly contained and discarded.

It is not advisable to enter an area with a propylene oxide leak because of the extreme flammability hazard. When entry into an area is necessary to contain or control a life-threatening spill, a full rubber slicker suit should be worn with pants outside rubber
boots. Chemical goggles and proper respiratory protection should also be worn. If a fire hazard exists, a suitable flash suit and hood should be substituted for the rubber slicker suit.

**Inhalation**

Propylene oxide may be irritating to the membranes of the respiratory tract and to the eyes. High concentrations may cause serious adverse effects, even death. In areas with poor ventilation, leaks or spills may result in accumulation of acutely toxic and potentially lethal concentrations. Signs and symptoms of excessive exposure may include eye and respiratory tract irritation, cyanosis, and possibly anesthesia and narcosis.

If overcome from inhalation of propylene oxide, a victim should be moved from the contaminated atmosphere into fresh air at once by persons properly equipped with appropriate personal protective equipment (PPE). Treat for shock if necessary. If the victim has stopped breathing, give artificial respiration. Caution should be used to prevent responder exposure to propylene oxide from the victim. If breathing is difficult, oxygen should be administered by qualified personnel. Once revived, keep the victim warm and calm. Seek prompt medical attention.

**Ingestion**

Exposure through ingestion of propylene oxide is unlikely. If propylene oxide should be ingested, give the patient, if conscious, lukewarm water. *Do not induce vomiting.* Because rapid absorption may occur through the lungs if aspirated and cause a systemic effect, the decision to induce vomiting or not should be made only by a physician. When stabilized sufficiently as determined by medical authorities, the patient should be transported to a medical facility for continued treatment.
The primary route of exposure to propylene oxide is through inhalation of fugitive emissions in the workplace. Propylene oxide is likely to be readily absorbed through the respiratory tract and rapidly metabolized by conjugation with glutathione, or hydrolyzed to 1,2–propane diol (propylene glycol). Acutely, propylene oxide is a severe skin, eye, and respiratory irritant.

Long-term studies in animals have clearly shown that chronic exposure to high levels of propylene oxide can induce site-of-contact malignant tumors and that propylene oxide should be considered a possible human carcinogen (see page 14, “Carcinogenicity”).

Consistent with good industrial hygiene practice, exposures should be carefully controlled to prevent adverse health effects; the ACGIH TLV (8-hr TWA) is 2 ppm. For more detailed toxicity information and the most recent Material Safety Data Sheet (MSDS), contact Dow.

**Acute Effects of Overexposure**

Single exposures to liquid propylene oxide can cause severe skin and eye irritation, which may lead to severe tissue injury if not treated promptly. There are reports in the literature that indicate that excessive exposure to liquid propylene oxide may induce allergic skin reactions in workers; ACGIH notes propylene oxide as a skin contact sensitizer. Exposure to high vapor concentrations can cause irritation of the eyes and respiratory tract, cyanosis, and possibly central nervous system effects such as coordination problems and general depression.

Propylene oxide generally does not cause adverse effects to the skin if it can freely evaporate. However, confinement under clothing or in shoes or jewelry prevents evaporation resulting in irritation, blistering, and possible burns. Contact with even dilute solutions of propylene oxide (10%) can cause irritation, blistering, and burns with a single short-term exposure.

Data from animal studies indicates that single exposure to propylene oxide by ingestion or by inhalation is moderately toxic.

**Repeated Exposures**

Repeated exposure to excessive levels of propylene oxide vapors may cause eye and respiratory irritation, and lung and nasal tissue injury. Effects to the nerves of the extremities (peripheral neuropathy) have been noted following extremely high (>1000 ppm), repeated exposures in laboratory animals.

In short-term, repeated animal exposure studies, concentrations of propylene oxide above 1000 mg/m³ (420 ppm) were irritating to the eyes and respiratory tract, causing lung edema (fluid in the lungs) and central nervous system depression. Repeated high oral doses of propylene oxide resulted in damage to the stomach lining and a slight depression of body weight.
Chronic Effects of Overexposure

Carcinogenicity

Long-term studies on rats and mice have shown that propylene oxide induces tumors at the first site of tissue contact. Tumors were produced through various routes of exposure, including inhalation, which is most relevant to industrial applications.

In two separate inhalation studies in rats, lifetime exposure to high levels of propylene oxide-induced adenomas in the nasal passages (at exposures ≥700 mg/m³ or 300 ppm).

In a third inhalation study, hyperplasia (an increase in the number of cells) in the target tissue of the nasal epithelium of the rats was reported, although no nasal tumors were identified; in addition, an increase in the total number of tumors in the tumor-bearing animals was reported.

On the basis of the data from these studies and others, propylene oxide is considered carcinogenic to experimental animals and has been classified as a possible human carcinogen (group 2B) by the International Agency for Research on Cancer (IARC). Consistent with the IARC classification, in the U.S., propylene oxide is listed as Reasonably Anticipated to be a Human Carcinogen in the National Toxicology Program’s Report on Carcinogens. In the EU, propylene oxide is classified as a Category 2 carcinogen, which indicates that propylene oxide may cause cancer.

Reproductive and Developmental Toxicity

Propylene oxide has been reported to have only minimal reproductive effects in male and female rats at high exposure levels (up to 300 ppm), with no significant variations from control animals in any of the reproductive indices measured. High exposure levels of propylene oxide (500 ppm) induced only minimal body weight changes in pregnant rats and a slight skeletal variation in the offspring. The EU’s Classification and Labeling authority does not consider propylene oxide to be a reproductive hazard in animals.

Genetic Toxicology

Propylene oxide is a direct alkylating agent and can interact with tissue macromolecules and produce adducts. The presence of tissue DNA adducts is evidence of exposure to propylene oxide. In in vitro microbial and mammalian cells test systems, propylene oxide is demonstrated to be a direct acting genotoxicant, producing mutations and chromosome aberrations. The evidence following in vivo exposure, however, is not conclusive. All of the in vivo cytogenetic and mutagenic data was negative with the exception of when propylene oxide was administered by injection into the abdominal cavity at high doses. In Europe, propylene oxide is listed as a Category 2 mutagen.
Taken together, the available information indicates that propylene oxide is able to react with genetic material forming adducts and, under certain extreme conditions, produce damage as evidence by mutations and chromosome aberrations. However, currently it has not been established that these findings are linked to any significant adverse responses in humans under usual conditions of exposure.

**Exposure Limits**

The companies strongly recommend that users comply with the ACGIH TLV guideline of 2 ppm (established in 2002). Users should remain aware of local TWA, STEL, PEL, or other occupational exposure level requirements. Propylene oxide users can find current information about ACGIH evaluations of propylene oxide on the organization’s web site (www.acgih.org). Current information can also be found on the Material Safety Data Sheet (MSDS) provided by Dow with shipments of propylene oxide.
System designs should focus on eliminating the need for personal protective equipment. However, personal protective equipment may be required in certain operations, or in locations where exposure to vapor or liquid is possible, such as in the event of a system failure. Identification of use requirements and selection of personal protective equipment demand careful management consideration.

An overall appraisal should be made of plant operations, exposure potentials, expected exposure duration, the specific activities being performed, and the training on personal protective equipment to be provided to workers. This appraisal should be performed by a qualified industrial hygienist in conjunction with engineering, maintenance, supervisory, and management staff. A written exposure control plan should be developed. The plan should identify:

- types of approved equipment (including manufacturer, make, and model);
- types of protective equipment to use for specific situations;
- procedures for maintenance, cleaning, and storage of the protective equipment;
- training required in proper use of the protective equipment; and
- other issues relevant to specific operations.

When selecting personal protective equipment and managing equipment programs, the overall assessment of potential exposures should be considered. Issues to be addressed include the following:

- Are there ways to reduce expected exposures by instituting changes in either equipment use or procedures?
- Is the exposure likely to be at levels above the occupational exposure guidelines?
- Is the exposure likely to be of very short duration, after which decontamination can be immediately accomplished, or is a lengthy exposure likely?
- Is the exposure likely to occur only once or twice per month as might occur in some unloading operations?
- Is single-use equipment desirable?

**NOTE:** The Material Safety Data Sheet (MSDS) for propylene oxide suggests that air purifying respirators, supplied air, or self-contained breathing apparatus be used depending on conditions and when respiratory protection is required.

### Eye Protection

Propylene oxide may cause severe eye irritation and possibly corneal burns. High levels of propylene oxide vapors may also irritate the eyes. Cup-type plastic chemical safety goggles—of gas-tight design and equipped with impact-resistant lenses—should be worn whenever there is potential for exposure to vapor or liquid. A face shield (8-inch minimum) may be worn to provide added splash protection. Or, if vapors cause eye discomfort, a full-face respirator should be worn. Eye protective measures should meet ANSI Z87.1 specifications.
Individuals wearing contact lenses while working with or around propylene oxide should wear chemical safety goggles at all times. The potential for an increase in eye injury of contact lens wearers exposed to chemicals has not been determined. A conservative approach in the selection of personal protective equipment is warranted.

Respiratory Protection

Propylene oxide has a sweet, penetrating odor that does not provide adequate warning to prevent overexposure. The odor threshold for propylene oxide for most people is between 10-200 ppm. However, the eight-hour TLV (threshold limit value) recommended by the ACGIH is 2 ppm and the OSHA PEL (permissible exposure limit) is 100 ppm. An active propylene oxide testing and monitoring program is recommended.

Atmospheric levels should be maintained below the appropriate exposure guideline for propylene oxide. When respiratory protection is required, use an approved air-purifying or positive-pressure supplied-air respirator, depending on potential airborne concentrations. For short-term or limited single-use situations, an approved air-purifying respirator with a cartridge for organic vapors is recommended. However, the limitations and benefits of using air-purifying respirators should be clearly understood.

For emergencies and other conditions when the exposure guideline may be exceeded (for example, in confined spaces or poorly ventilated areas), use an approved positive-pressure self-contained breathing apparatus or positive-pressure airline with an auxiliary self-contained air supply.

General Protective Clothing

Even well-engineered systems will require the use of personal protective clothing in the event of spills or other potential exposure situations.

NOTE: Personnel should be required to wear “work” clothes, stored separately from their “street” clothes. This allows the industrial laundry to handle and wash work clothes that could be chemically contaminated.

In all operations involving propylene oxide, and where employee exposure is possible, workers should wear chemical workers’ goggles, safety hats, impervious boots, gloves, and protective outer clothing.

Trousers should be worn outside the boots and sleeves should be taped to gloves (with tapered sleeve inserts between sleeve and glove) to prevent contact of propylene oxide with the skin.

Clothing type, make, and materials of construction should be carefully evaluated using an “exposure control management” approach that evaluates each potential exposure situation. For example, protective clothing for splash protection (which is disposed of or immediately cleaned after exposure) may not need to be as durable as protective clothing for continuous exposure situations. Thoroughly evaluate the data supplied by your clothing manufacturer,
paying particular attention to the expected clothing performance in the event of exposure to propylene oxide.

It is important to recognize the hazards associated with the choice of clothing materials. For example, leather is a hazard when contaminated with propylene oxide and should not be specified for use. Leather can absorb propylene oxide and maintain a low exposure level over a prolonged period of time, causing a severe burn before discomfort registers.

It is also necessary to set guidelines for decontaminating and destroying protective clothing. Leather articles should be destroyed to prevent accidental reuse.

Impervious Gloves and Clothing

The following information is provided with the caution that it should be understood that gloves and clothing are used as a means of preventing incidental contact only.

When choosing impervious protective clothing, there are several factors to consider in addition to the intrinsic barrier properties. Performance factors to consider include:

- Thickness of clothing material.
- Permeation resistance to propylene oxide and other chemicals with which the clothing may come in contact.
- Fabrication technique (particularly how seams are sealed and/or constructed).
- Laminate construction, if applicable.
- Physical requirements of the clothing that may be required depending on specific conditions of use, such as strength, dexterity, abrasion and tear resistance, or thermal protection.
- Duration of potential exposure.
- Other factors specific to your application or use.

Customers are strongly advised to obtain information from clothing and safety equipment suppliers about product performance in given situations and the barrier properties of the protective equipment to propylene oxide. Selection of specific items such as face shields, gloves, boots, apron, or full body suit will depend on the specific operation as well as characteristics of the items themselves.

Examples of glove barrier materials that have been found to be protective in propylene oxide exposures include:

- butyl rubber,
- chlorinated polyethylene,
- polyethylene,
- ethyl vinyl alcohol (EVOH) laminate,
- polyvinyl alcohol (“PVA”), and
- styrene/butadiene rubber.

In specific situations, and depending on supplier information, natural rubber (“latex”), Neoprene®, nitrile/butadiene rubber (“nitrile” or “NBR”), polyvinyl chloride (“PVC” or “vinyl”), or Viton® may be acceptable.
Protective Equipment Training

The key to a successful program is training personnel in the use of protective equipment. Without a good understanding of the ways the protective equipment works and its limitations, as well as of correct maintenance procedures, the expected protection factors are unlikely to be achieved. Specific properties of propylene oxide, such as toxicity of propylene oxide vapors through skin exposure, and the protection required to mitigate the effect should be part of the training program. A well-designed training program also includes instruction in the proper way to wear, use, clean, and maintain each piece of equipment.

Respirator use requires medical approval for each individual user and a personal fit-test to ensure effective protection. Details regarding respirator use can be found in 29 CFR §1910.134.

Training should be documented and reviewed with each employee on a regular basis with retraining scheduled on a specified and regular basis.
Three different methods are recommended for sampling propylene oxide—on-stream analytical equipment, safety-coated glass bottles, or stainless steel cylinders. Whichever method is used, procedures and equipment should be carefully designed to minimize personnel exposure or venting to the atmosphere.

**On-stream Methods**

On-stream sampling equipment has two advantages in propylene oxide operations. First, personal exposure levels are kept to a minimum. Second, sample collection does not expose samples to the air. Isolating samples from the atmosphere is important for propylene oxide, which, because of its hygroscopic nature, will pick up water from the air if an open sampling system is used, resulting in an artificially high apparent water content.

**Manual Methods**

**Safety-Coated Glass Bottle Method**

Consider minimizing the dead-volume and allow the sample to be collected with very little purging.

Bottle caps should have a polyethylene seal to prevent contamination from a glued or paper seal.

- To minimize personnel exposure, use either closed-loop sampling or surround the sample point with a box connected to a vacuum source. The airflow volume must be great enough to create the same velocity across the open door face as is required in a laboratory hood.

- Because of the hygroscopic nature of propylene oxide, samples may indicate an artificially high water content when this method is used.

- Materials should be below about 32°C (90°F) when collecting samples in bottles to prevent over-pressuring.

**Stainless Steel Cylinder Method**

- For propylene oxide samples, a DOT 3E cylinder with a service pressure of 1800 psig should be used. The specification for this cylinder is outlined in 49 CFR §178.42.

- Screwed connections must be sealed. A polytetrafluoroethylene (PTFE) tape with appropriate chemical properties may be used.

- A relief valve should be provided on the cylinder assembly.

- The cylinder should contain a dip tube to prevent it from filling hydraulically.

- The contents and sampling date should be clearly marked on the cylinder.

- The cylinder may be evacuated, connected to a low dead volume sample connection, filled, and then disconnected; or connected to a constant recycle flow-through system, flushed, filled, and then disconnected.

**Other Safety Considerations**

- A safety shower with eyewash capability should be located near the sampling point.

- The area around the sample location should be free of ignition sources and other hazards.
Sampling Equipment

- Sampling containers should be clearly labeled and dedicated to propylene oxide service to minimize the chance of contamination or possible violent reactions.
- Only the amount of sample needed for analysis should be collected, and any residue must be disposed of according to all applicable rules and regulations.
- Avoid smoking areas, control rooms, and areas where “hot work” is in progress when transporting samples to the laboratory.
- All laboratory equipment used in analyzing propylene oxide samples (such as the ventilation hood and refrigerator) should conform to electrical standards equivalent to Class 1, Division 1, Group B* of the NFPA 70, National Electrical Code.
According to the Occupational Safety and Health Administration (OSHA), the chemical industry in the U.S. has one of the best safety records of any industrial sector. To maintain—and even improve—this superior safety record, it is very important that chemical manufacturers and processors establish an effective, well-developed plan to ensure quick and effective response to emergencies.

Emergency planning should consider all aspects of emergency situations, including not only those that may occur on-site, but also incidents that may occur en route to the site, in the surrounding community, or in the community at large.

This section describes a process for emergency planning and provides specific information about spills, fire-fighting, and associated waste disposal. Plans should be developed with the assistance of local fire fighters and other emergency response personnel.

**Plan Development**

Many organizations have published comprehensive guidance on developing crisis management plans. For example, OSHA has developed a booklet called *How to Plan for Workplace Emergencies and Evacuations* (http://www.osha.gov/Publications/osha3088.html). The discussion presented here is not all-encompassing; rather, general principles important for propylene oxide users to consider are discussed.

One of the first steps in developing a crisis management plan is to define various potential crisis scenarios as they are related to planning, preparation, mobilization, response, recovery, and post-incident follow-up. The process should be comprehensive and consider all aspects of potential emergencies, including warning alarms, evacuation assembly areas and escape routes, personnel accountability, communication vehicles, chain of command, notification of authorities, dealing with the media, and other important concerns. If your plant does not have a crisis management plan, it is recommended that one be developed.

Assuming that a general plan exists for your facility, the task of preparing for a new installation starts with proper design. Engineers should design the bulk storage and handling system to minimize hazardous conditions and to allow quick response if emergencies occur. For example, the use of nitrogen padding is recommended on propylene oxide storage vessels to eliminate oxygen from the vessel and thereby reduce the risk of fire. An excellent way to test a new design is to perform a process hazard analysis. As part of the hazard identification and management process, it is also important to develop safe operating procedures.

After completing both an overall crisis management plan and a process hazard analysis, the next logical step is to develop written procedures for responding to possible emergencies associated with the new installation. These plans should be carefully
tied into the emergency plan and cover all of the aspects required in the overall plan. The procedures should also include a specific plan for controlling the emergency. Procedures should cover all parameters, including fire extinguishers and other fixed fire protection equipment, emergency block valves, spill containment, personal protective equipment and clothing, and so on. All post-emergency procedures, such as waste cleanup, waste disposal and equipment checks, and proper reporting should also be considered. The plan should be tested in a simulated situation to ensure its effectiveness in a real emergency.

Another important step in developing an emergency plan involves community interaction. The plan should be integrated into the community-wide emergency response plan.

**Fire Hazards**

The Occupational Safety and Health Administration classifies propylene oxide as a Class 1A flammable liquid. The National Fire Protection Association (NFPA) Code 30 defines propylene oxide as a Class 1A flammable liquid. For application of the National Electrical Code, propylene oxide is a Class 1, Group B* flammable liquid.

Vapors of propylene oxide at concentrations between 1.6% and 42% in air can explode if an ignition source is present. Propylene oxide vapors are heavier than air and may travel a considerable distance toward a source of ignition and flash back. All precautions necessary for the safe handling and storage of a volatile flammable liquid or vapor should be strictly observed for propylene oxide. Aqueous mixtures as low as 0.75% propylene oxide may be flammable.

Storage areas should be designed to prevent exposure of propylene oxide containers to hazards from potential fires (see page 30, “Bulk Handling”). Page 38, “Delivery & Transfer,” includes recommendations for the safe unloading and transfer of propylene oxide, which are necessary to minimize the fire and explosion hazard while performing these operations.

If propylene oxide is involved in a fire, prevent unauthorized individuals from entering the area, and evacuate the area downwind from the fire. Fires should be fought from a safe distance upwind. Thermal decomposition products, such as carbon dioxide, carbon monoxide, and perhaps other toxic gases and vapors, may be generated. Propylene oxide, when involved in a fire, burns rapidly with tremendous heat. Table 1 (page 4) and Figure 1 (page 7) provide propylene oxide flammability limits.

**Fire Prevention and Protection**

Propylene oxide, when ignited, burns rapidly with high heat. Because of the high vapor pressure of propylene oxide, it is capable of readily forming explosive mixtures. Sources of ignition, including heat, sparks, flames, and static electricity, must be avoided. Compliance with this basic rule requires continual oversight and management that should typically include the following combination of work practices and mechanical controls:

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1. 29 CFR §1910.106
2. NEC-NFPA 70
3. See Figure 1 on page 7.
Emergency Planning

- Defining “no smoking” and “hot work” policies in areas where propylene oxide is used;
- Using non-sparking tools if working in an area where propylene oxide vapors could be present;
- Grounding metallic containers/vessels in which propylene oxide is stored;
- Bonding and grounding metallic receiving containers;
- Enforcing stringent welding, cutting, and burning permit systems; and
- Implementing inside and outside storage methods that comply with legal requirements and good industry practice.

Tanks and equipment containing liquid propylene oxide should be protected with automatic deluge or sprinkler systems including coverage of pumps and shaft seal areas (per NFPA design criteria). A manually activated, remotely located switch should also be provided.

The use of installed flammable (combustible) gas detectors in at-risk areas—such as those around propylene oxide pumps or loading and unloading operations—is recommended. Heat may create a build-up of pressure and cause closed containers to rupture. A water fog may be used to cool the containers. Water may be ineffective as an extinguishing agent. Prevent liquid from entering external water sources and sewers by building dikes as necessary to contain flow.

Per the NFPA, the electrical classification for well-designed and maintained propylene oxide handling areas is Class 1, Division 2, Group B*. Areas where the presence of propylene oxide vapors is probable, such as immediately above tanks or vessels, near vents, or within buildings or retaining walls should be classified as Class 1, Division 1, Group B*.

Static Electricity

The transfer of propylene oxide can create static electricity charges, which can act as an ignition source for flammable vapors. The charge can develop even when the liquid flows or is poured through air. To minimize the risk of ignition, bonding and grounding of equipment is required by federal regulation (29 CFR §1910.107), building and fire codes, and industry practice (NFPA 70, NFPA 77, NFPA 30). Bonding provides a low-resistance path to current flow between two surfaces that are physically separated or become separated. Per NFPA 77, a maximum of 1 megaohm is acceptable, though lower values reduce risk.

Grounding connects the containment vessels, pipes, etc., to a grounding electrode (ground) in the earth by means of conductors welded or attached to both the equipment and the ground.

Filling vessels and containers through a dip tube or through a bottom nozzle to minimize the static created by free-falling liquid is recommended.
Fire and Explosion

Propylene oxide fires can be difficult to extinguish because of the material’s low flash point and high vapor pressure. Consider the use of water fog, dry chemical, alcohol foam, or carbon dioxide when fighting fires. Water may be used to cool propylene oxide containers exposed to a fire to reduce the potential for a BLEVE (Boiling Liquid Expanding Vapor Explosion). If a leak or spill has not ignited, water fog may be used to disperse the vapors and to provide protection for workers attempting to stop a leak. Water fog may also be used to flush spills away from potential ignition sources, bearing in mind that an aqueous solution as low as 0.75% propylene oxide may still be flammable.

Those who may come into contact with the vapors should wear appropriate safety equipment, such as a positive-pressure, self-contained breathing apparatus. If contact with vapors is possible, wear full protective clothing.

For more information, review the Flammable and Combustible Liquids Code (NFPA No. 30), National Electrical Code (NFPA No. 70), Lightning Protection Code (NFPA No. 78), and Fire-Hazard Properties of Flammable Liquids, Gases and Volatile Solids (NFPA No. 325M).

Fire Fighting

If your facility relies on community fire companies for fire response, information regarding propylene oxide operations and storage should be provided to the responders. Information should include facility layouts indicating the storage locations and quantities of propylene oxide. Drills should be conducted periodically with the fire company, and facility information should be updated on a regular basis.

If your facility has chosen the option of an internal fire brigade for structural fire fighting, compliance with the OSHA Fire Brigade Standard is required. These requirements, as defined in 29 CFR §1910.156, include the organization of a fire brigade, personal fire fighting equipment, and training requirements.

Fire fighters should use full protective clothing and equipment, including National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA)-approved self-contained breathing apparatus with full facemask operated in the pressure demand mode (see page 12, “Inhalation” and “Ingestion”). Water spray can be used to disperse vapors to protect the fire fighters that may be attempting to stop a leak.

If a fire is controllable or propylene oxide containers are not exposed to direct flame, an evacuation zone with a minimum radius of 1,500 feet may be needed. If the fire becomes uncontrollable or propylene oxide containers are exposed to direct flame, an evacuation zone with a minimum radius of 5,000 feet may be required. In some instances, depending on specific facility hazards, it may be prudent to allow a propylene oxide fire to burn itself out. A qualified fire fighting expert should make this decision.
After a fire has been extinguished, residual propylene oxide contamination may occur. Residual contamination may require a cleanup of the liquid. Individuals who engage in such a cleanup should be thoroughly trained in proper techniques and have received training in accordance with the OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) standard, 29 CFR §1910.120.

**Fire Suppression**

Some foam systems may be used to extinguish fires, but the effectiveness of the foams must be reviewed with the foam manufacturer. The intensity of a propylene oxide fire may significantly diminish the effectiveness of certain foams. Foam applied directly to open surface fires will require a higher concentration, a higher application rate, and/or repeated applications. Because of propylene oxide’s low flash point and high vapor pressure, propylene oxide may reignite from hot surfaces.

The emergency response plan (see page 22, “Plan Development”) should include the amount and locations of extinguishing equipment necessary to extinguish a propylene oxide fire and an evaluation of a worst-case fire scenario is prudent.

Propylene oxide is soluble in water and the resulting solution requires substantial dilution to control the vapor above the mixture. In confined spaces such as sumps or sewers, a dilution factor greater than 150 to 1, or less than 0.75% propylene oxide, may be necessary to prevent vapor concentrations above the 20% lower exposure limit (LEL).

Portable fire extinguishers should be placed in the vicinity where propylene oxide is handled or stored and in locations where the potential for spills or leaks exists. Class B dry chemical or foam extinguishers should be used when fighting small propylene oxide fires. NFPA10 contains guidelines for the correct selection, use, distribution, inspection, maintenance, and recharging of portable fire extinguishers and should be referred to when designing a work area.
Aqueous solutions of propylene oxide degrade in the environment and are hydrolyzed to propylene glycol with an average half-life of 13 days. The length of time for propylene oxide degradation varies depending on conditions of the aquatic medium. Aquatic organisms can metabolize propylene glycol. Propylene glycol is classified as readily biodegradable.

\[
\begin{align*}
C_3H_6O + H_2O &\rightarrow C_3H_8O_2 \\
\text{Propylene Oxide} &\quad \text{Water} \rightarrow \text{Propylene Glycol}
\end{align*}
\]

Propylene oxide may contaminate soil if accidentally spilled and spread by rain or groundwater. Degradation in wet soil occurs through hydrolysis to propylene glycol. In dry soil, propylene oxide evaporates into the air.

Studies indicate that propylene oxide, because of its water solubility and conversion to propylene glycol, does not accumulate in aquatic or terrestrial life forms.

**Spills and Leaks**

Facilities in which propylene oxide will be stored and/or handled should be designed to contain and/or control spills in process areas as well as in loading/unloading operations. Soil and groundwater contamination that may result from an accidental spill of propylene oxide can be minimized by installation of curbs, sumps, and impervious containment areas.

Concrete curbs or earthen dikes should be sloped from the point of the potential spill to a collection basin or sump and should be used to retain propylene oxide within the containment area, thus minimizing worker exposure and overall environmental impact. The total volume of the containment area should be adequate to handle a worst-case release of propylene oxide. For storage tanks, the capacity of the containment area is, at a minimum, generally the volume of the largest storage tank in the dike area. Dike or curb design should provide an allowance for accumulated rainfall.

Pumps, piping, and equipment designed to operate within potential spill areas should be compatible with propylene oxide and free of potential ignition sources.

If possible, all pumps and ancillary equipment should be located outside the primary containment area and should be provided with curbing to collect drips, leaks, and minor spills. Drain valves may be installed at the low point of the containment area or sump. During normal operations, all drain valves should be in a closed position.

The reportable quantity (RQ) for propylene oxide spills in the U.S. is 100 pounds. In the event of a propylene oxide release to the environment equal to or greater than 100 pounds, the National Response Center must be notified. The telephone number of the National Response Center is (800) 424-8802. This reporting requirement is a provision of Sections 103(a) and (b) of the Comprehensive Emergency Response, Compensation and Liability Act of 1980 (CERCLA), as amended. Reportable quantities are listed in 40 CFR §302.4, Table 302.4.
Environmental Protection Agency  
National Response Center  
IN CASE OF PROPYLENE OXIDE RELEASE  
OF 100 OR MORE POUNDS  
NOTIFY  
1-800-424-8802  

In addition to the above reporting requirement, Section 304 of the Superfund Amendments and Reauthorization Act of 1986 (SARA) requires that a release to the environment of hazardous substances in quantities equal to or greater than the applicable RQ be reported to state and local authorities. These agencies are location specific and should be included in the facility’s emergency response plan.

Any accidental discharge of propylene oxide or waste containing propylene oxide into the municipal sewer system should be reported immediately to local authorities. The discharge should be diluted with copious quantities of water to reduce the fire and explosion hazard. National Pretreatment Standards, 40 CFR §403.5, prohibit the discharge of pollutants that may create a fire or explosion hazard in the sewer system or publicly owned treatment works.

In the event of a spill of propylene oxide, all non-essential personnel should be evacuated. All ignition sources must be extinguished immediately. After donning the appropriate personal protective equipment (see page 16, “Personal Protective Equipment”), the spill should be covered with water spray or foam to minimize potential fire hazard from vaporization of the propylene oxide.

Depending on the volume and location of the spill, recovery by a vacuum truck may be suitable. Residual propylene oxide in the containment area should be flushed with water into a sump or collection area for subsequent treatment or disposal.

Waste Disposal

Propylene oxide is a flammable liquid and is hazardous when discharged to the environment. In areas where propylene oxide may be released or handled, access should be limited to required personnel only.

Occupational Safety and Health Administration regulation 29 CFR §1910.120 applies to the handling of spills of propylene oxide waste. This regulation applies to personnel engaged in the following activities: hazardous waste response under CERCLA, cleanup operations under the Resource Conservation and Recovery Act (RCRA), operations involving hazardous waste storage, hazardous waste sites, and emergency response.

Aqueous solutions containing low concentrations of propylene oxide can be treated biologically in a waste treatment plant. Biological treatment can also be considered for disposal of minor spills provided that the system is acclimated to propylene oxide and propylene glycol, and the treatment system has any required permit approvals.

Incineration of contaminated soil and liquid propylene oxide is also an acceptable disposal alternative.
If propylene oxide process waste is treated biologically at a publicly owned treatment works facility, the local authority should be consulted to determine appropriate requirements. If propylene oxide is biologically treated on-site and then discharged to surface waters, the treatment plant effluent should comply with applicable federal, state, and local discharge permit provisions.

All waste disposal of propylene oxide should comply with all applicable laws and regulations.

Absorbents

Clay-based absorbents should not be used because they can react with propylene oxide resulting in the evolution of heat (see page 3, “Instability and Reactivity Hazards”). Heat from this reaction can result in spontaneous combustion as auto-ignition temperatures can be reached.

In general, high surface area absorbents may result in generation of flammable vapors. Therefore, the use of water, rather than absorbents, is the preferred method of cleaning up a propylene oxide spill.
Some important considerations in the design and construction of propylene oxide storage and handling facilities are flammability, environmental contamination, volume, and worker exposure. Specific design requirements for propylene oxide receiving and storage facilities and for handling propylene oxide depend on several factors, including volumes stored or handled, container type, mode of transportation, processes used at the facility, proximity to other hazardous materials, and the applicable laws and regulations regarding the storage and use of propylene oxide.

**General Design Considerations**

Systems for unloading, handling, and storing propylene oxide require the same analysis and design expertise as systems for other hazardous chemical products. The following information lists general considerations important in designing such systems.

Fragile devices such as glass or plastic sight and gauge glasses, bull’s-eye flow indicators, and other such devices are subject to failure from shock and thus should not be used in piping systems, vessels, or equipment in propylene oxide service. Expansion bellows or flexible connections should not be used in fixed or permanent propylene oxide piping installations.

Gaskets of spiral-wound stainless steel with flexible graphite or PTFE filler and circumferential internal and external metal retaining rings are preferred for pipe and vessel flanges. Metal-reinforced flat flexible graphite gaskets are also acceptable in class 150 and 300 service. Valve bonnet gaskets and pump body gaskets must be of spiral-wound stainless steel with flexible graphite or PTFE filler, or metal-reinforced flat flexible graphite gasket.

Few elastomers are suitable for liquid propylene oxide service. Elastomers such as Chemraz 505® and Kalrez 2035® are acceptable.

Generally, insulation is not needed on propylene oxide transfer piping and equipment. If required, select an insulation material that is neither reactive with, nor soluble in, propylene oxide. Known acceptable materials include glass foam, expanded perlite, and certain polyurethane-type insulating materials. Other insulation materials should be tested prior to use.
Figure 3  Typical Pressure Storage Tank Configuration

This figure illustrates a typical configuration, and is not intended to be used as a design specification. Qualified professionals must exercise engineering judgment to establish site specifications that meet applicable requirements.

- Pressure Safety Valve
- Tank Support
- Tank Drain
- Safety Railing
- Manway
- Level Transmitter with Output Gauge
- Outlet Line
- Approved Ground
- Filter
- Pump

- Pressure Gauge with Diaphragm Seal
- Pressure Controller (Split Range)
- Pressure Control Valve
- NFPA Identification Code
- Block Valve
- Check Valve
- Containment Dike
- Temperature Indication
- Level Transmitter

MAXIMUM FLOW CAPACITY OF PRESSURE CONTROL VALVE (13) SHALL NOT EXCEED RELIEF CAPACITY OF PRESSURE SAFETY VALVE (1)
Vessels

Storage vessels, pressure vessels, and equipment that will contain propylene oxide at operating pressures above 15 psig (1.02 bar) should be designed in accordance with the ASME (American Society of Mechanical Engineers) Boiler and Pressure Code or equivalent standards.

Storage and process tanks designed to contain propylene oxide with operating pressures less than 15 psig should be designed in accordance with API (American Petroleum Institute) standard 620 or equivalent standards. The design pressure of API 620 tanks should be as high as practical, at least 5 psig for tanks larger than 50 feet in diameter and a minimum of 10 psig for smaller tanks. Requirements for vessel storage, including secondary containment, are presented in NFPA 30. Considerations in site selection and tank spacing include proximity to other flammable material storage facilities, nearby sources of ignition, accessibility for fire-fighting equipment, and impact of a vapor cloud explosion on nearby areas. Installations should comply with NFPA 30 and NFPA 70 regarding these issues. These standards are intended to ensure that tanks possess sufficient structural strength and pressure relief systems to prevent catastrophic loss of contents in either normal service or under fire conditions.

Storage tanks should be situated within containment systems that are equipped to provide detection and control of an accidental release of propylene oxide.

Storage tanks and facilities for loading and unloading propylene oxide from tank cars or trucks should have spill retention walls, dikes, or curbs to direct spills into containment areas, which are sufficiently remote to accommodate safe recovery or disposal. If tanks are grouped, the pond should hold 110% of the largest tank’s capacity, or be large enough to accommodate a volume of deluge water that allows adequate time to detect and rectify a significant leak or spill. The routing of propylene oxide to the impounding area should avoid possible ignition sources, and should not expose other storage or process systems to damage in the event that the spillage is ignited. Routing through underground lines with fire seals is preferred. Containment system design and operation should conform to NFPA 30.

Instrumentation at the unloading station should warn the operator of the potential for overfilling and activate a totally independent flow shut-off device whenever overfill is imminent. The device should not be used as a regular operating tool for determining tank level. Bulk storage tanks should be vented to a containment device, which eliminates discharges of propylene oxide vapors to the atmosphere. The containment device should be designed to prevent the passage of a flame from one container to another.

All tanks and vessels should be protected from over-pressure. Pressure relief systems should employ dual installation, three-way
pressure relief valves, so one valve is in service at all times. Discharge from pressure relief valves should not be manifolded and should be directed away from equipment, piping, and personnel. Design of safety valves should consider the possibility of fire damage to the vessel being protected. Rupture discs, used in conjunction with pressure relief valves, should be provided with a bleed-type opening between the disc and valve, and the connection should be piped into the relief valve discharge piping through a restricting orifice. A combustible gas detector that activates an alarm should be placed downstream from the bleed return and relief valves.

Design all vessels so that propylene oxide cannot free-fall through the vapor space of the vessel. One design that has been found effective is to install dip legs with siphon breakers in vessels where entry is through the upper portion of the vessel. Design all tanks and equipment to eliminate stagnant areas where little or no fluid turnover occurs in either the vapor or liquid. Flat-bottomed pressure storage tanks should be designed with foundations that will withstand the compression load of the tank full of water, and should be reinforced with a head stiffening ring and anchored around the bottom. The number of vessel nozzles should be held to a minimum. Special attention should be given to all normally active nozzles in the liquid zone, as these should be fitted with motor-operated emergency block valves.

Both local and remote operation of the valves should be provided. The valves should fail closed in the event of instrument air or electrical failure. The closure rate of the emergency block valves should be adjusted so as to prevent hydraulic shock upon closure.

Emissions resulting from loading and unloading operations should be controlled using contained systems; vapor balancing and product recovery are the preferred methods. Vents may be directed to flares or incinerators, provided they are remotely located and are designed with flame arrestors and associated instrumentation to prevent flashback.

Refrigeration and insulation of storage tanks are necessary only when dictated by the user’s process. For refrigerated storage of propylene oxide, cooling by plate coils attached to the tank exterior is recommended to prevent possible contamination by the coolant. When a greater degree of cooling is required, an external heat exchanger with propylene oxide circulation is recommended over an internal coil.

Instrumentation situated on or in propylene oxide tanks and vessels should meet electrical classification NFPA 30 guidelines [Class 1, Group B*]. Instrumentation should be designed so that propylene oxide will not make contact with energized electrical connections and will not enter air supply lines because of a ruptured diaphragm or other failure.
The minimum recommended instrumentation for propylene oxide vessels is:

- Temperature, levels, and pressures indication gauges (recording instruments are preferred).
- Audio-visual alarms for high temperature, high and low pressure, and high-fill-level limits.
- A second high-fill-level device set to actuate an alarm at a higher level than the first and to automatically close the motor-operated block valve in the fill line.
- An automatic pad and depad system using nitrogen as the pad gas on all storage vessels. Devices to prevent backflow should be installed in the nitrogen supply line as well as the process lines. A high-purity nitrogen supply should be used and must not contain ammonia or amines.

Flammable (combustible) gas detectors should be uniformly dispersed around equipment containing propylene oxide. The dispersion pattern should ensure coverage regardless of wind direction. Locating detectors at low points near drainage structures and outlets in process and storage areas is also advisable.

**Piping**

The piping system should comply with the latest edition of American Society of Mechanical Engineers/American National Standards Institute (AMSE/ANSI) B31.3. The following key points should be considered in any propylene oxide piping installation:

Piping should be welded and flanged. Minimize potential leak points by minimizing the number of valves, flanges, couplings, etc. Use of threaded connections is not advisable. Integrally reinforced fittings or reinforcing pads should be used for branch connections 1-1/2 inches and under in size. All pipe nipples used for instrumentation and test connections should be of minimum schedule 80 thickness.

Steam tracing should not be installed on propylene oxide piping. Piping systems should not be manifolled together with systems containing other products. The design of piping systems should prevent backflow of process materials into storage facilities, and should allow for pressure relief due to liquid expansion in the entire system, as well as sections that can be isolated using valves. All inactive terminal connections in oxide piping should be plugged or blinded. No galvanized piping should be used in propylene oxide service.

Lines that are buried should be of welded construction. Flange connections should not be used, except in valve boxes with access for service. Cathodic protection should be provided for buried lines.

**Valves**

Valves should meet fire-tested design requirements to API607. Ball valves should have self-relieving seats, due to potential thermal expansion from trapped liquids.
Centrifugal pumps with bodies and wetted parts constructed of cast steel or stainless steel are recommended. Double mechanical seals with buffer fluid (such as propylene glycol), or double-dry gas seals and monitoring instruments are recommended. The seals should be fitted with carbon stationary elements and tungsten rotating elements. The resilient or compressible components of the seal assembly should be of ethyl-propyl rubber or fluoroelastomer (for example, Chemraz 505® and Kalrez 2035® are acceptable for propylene oxide service). Pumps with double-dry gas seals should have provisions made for venting the pump before starting.

Pumps should be installed within dike or curbed areas, with the dike or curb sloped to direct any leaks or spills to a secondary containment area. Preferably, pumps should not be located in the same primary containment area with storage tanks.

Seal-less pumps, such as magnetic drive pumps, are also acceptable for use in propylene oxide service. Care should be taken to ensure that the pumps are not run dry to prevent damage to the pump.

Pumps used to unload propylene oxide should be sized accordingly, considering the excess flow check valves that are installed on the rail cars and trucks. Interlocking grounding devices with alarms should be used with the transfer system to provide an automatic shutdown if the grounding is lost. An interlock should also be used to prevent over-flowing the storage tank.

All pumps should be protected against abnormal temperature rise by a high-temperature alarm and shutdown. The sensing element should be of a Class 1, Group B* electrical classification and preferably should be located in the pump body. Locating the device immediately adjacent to the discharge piping before the first block valve may be a suitable alternative.
Work Preparation

Appropriate procedures for tank cleaning and equipment repair are necessary to prevent exposure to hazardous chemicals. Preparation should include a clear definition of the tasks to be performed, an identification of hazardous materials, and related hazardous conditions. A hazardous work permit system should be used to identify the job-related hazards and plan for the safe completion of this work. Employee protection should include the use of engineering controls (see page 30, “Bulk Handling”) and the selection of personal protective equipment (see page 16, “Personal Protective Equipment” and 29 CFR §1910.133–136).

Empty tanks and equipment that contained propylene oxide vapor or liquid should be cleared of residual material before cleaning and/or repair. Liquids should be removed from a low point of the vessel. Residual liquid and vapor should be flushed with water or another suitable material, and vapor should be purged with nitrogen (see “Confined Space Entry,” following). Flush and sweep materials should be disposed of properly to prevent release to the environment (see page 27, “Environmental,” and page 30, “Bulk Handling”).

Only properly trained workers should be involved in the cleaning and repair of tanks and equipment that have previously held propylene oxide (see page 16, “Personal Protective Equipment” and HAZWOPER 29 CFR §1910.120).

Eyewash and safety showers should be located near the work operation. Appropriate fire extinguishing equipment should be present (see page 22, “Emergency Planning,” and 29 CFR §1910.38).

Control of Hazardous Energy

A facility must have procedures for controlling hazardous energy sources that comply with the requirements of 29 CFR §1910.147. The procedures protect workers in areas where propylene oxide vessels or equipment are cleaned, maintained, or entered. After the system is purged, ensure that all potential sources of propylene oxide or hazardous energy are physically tagged and/or locked out, and affected persons notified.

Confined Space Entry

The Occupational Safety and Health Administration establishes requirements for entry into confined spaces (29 CFR §1910.146). Precautions should be taken to prevent asphyxiation from any inert gas flush operation, such as nitrogen purging.

Appropriate respiratory protection for propylene oxide vapor exposures (see page 17, “Respiratory Protection” and 29 CFR §1910.134) may also be required.

Equipment Cleanout and Recommissioning Vessels

If a new tank is to be put into service, it is critical that it be clean of all rust, dirt, grease, and water. Soap or detergents and water should be used to remove grease and
oils. The cleaned surface should be rinsed with water until a neutral pH is obtained. No solvents containing organic or inorganic chlorides should be used.

Iron oxide is a catalyst for propylene oxide polymerization. To eliminate loose rust (iron oxide) and scale from inside a tank, a high-pressure freshwater blast is effective. Acidic or basic cleaning or pickling systems should be avoided because their residues can cause vigorous reactions with propylene oxide. After this step, the tank walls should be dried and the bottom cleaned of all solids and water. The tank should then be purged with nitrogen gas to below 2% concentration of residual oxygen.

Maintenance and Inspection

Preventive maintenance and inspection of containers, hoses, pumps, fittings, fire protection equipment, and refrigeration units used for propylene oxide should be conducted. An adequate supply of spare parts for refrigeration units should be maintained. Overpressure and overfill detectors and flammable (combustible) gas detectors should be maintained and calibrated regularly.

The inspection program should also include appropriately scheduled inspection of equipment storage areas and ventilation systems. Preventive maintenance schedules should be developed for critical equipment such as tank instrumentation, fire fighting equipment, combustible gas detectors, pumps, safety relief valves, gaskets, and emission control equipment.
Prior to delivery, customers should be prepared to safely receive, off-load, and store propylene oxide. To promote safety and security (see page 53, “Security”), Dow will make deliveries only to sites with which it is familiar or has otherwise been assured that the personnel are capable of safely handling propylene oxide. In general, this normally means that the site will be visited and reviewed by a representative from Dow prior to the its first delivery.

It is important to carefully instruct all personnel involved in plant design and the handling of propylene oxide on the properties of this material. Because the degree of hazard varies from one operation to another, individual situations should be carefully evaluated to determine all appropriate safety measures.

A variety of vessels—including rail tank cars and tank trucks—are used to transport propylene oxide. All appropriate national and international regulations must be met.

For regulatory requirements concerning unloading and storage of hazardous chemicals, Title 49 of the Code of Federal Regulations, the United States Department of Transportation (DOT), should be consulted. Because governmental requirements may differ between local, state, federal, or other sovereign authorities, a full review of all applicable laws and regulations should be completed before designing and installing a storage and unloading facility.

Considerations for Delivery

The following are some considerations designed to help prepare for an initial bulk delivery to a new facility. For specific information about hardware, you may want to contact Dow.

- Has Dow visited your facility and reviewed your bulk propylene oxide handling and storage facility?

  NOTE: Dow may decline to deliver to a facility until an on-site review is conducted to verify that the facility meets Dow’s minimum standards.

- Is it necessary, or preferable, for Dow 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?

  NOTE: Any water in the system can create quality and safety problems.

- Was the off-loading pump tested with liquid after installation?

- 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?
NOTE: It is recommended that the spill-containment volume is large enough to hold the entire contents of the vehicle scheduled for off-loading.

- Are there valve position changes required to secure the containment system? If so, are they described in the off-loading procedure?
- Are spotting, choking, 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 appropriate personal protective equipment available to the operator before off-loading? Is the equipment specified in a procedure?
- Are the safety shower and eye wash stations immediately accessible in the off-loading area?
- Are the safety showers and eye wash stations 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?
- How will the vehicle’s electrical ground be verified?
- Has the off-loading operator received training on the hazards of the product and reviewed current Material Safety Data Sheets (MSDS)?

- 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 invoice and Certificate of Analysis?

NOTE: Product stencils and accompanying documents on rail cars also should be checked.

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

NOTE: If so, what precautions will be taken to avoid personnel exposure?

- 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 2%?
- Are all terminal lines plugged (blinded) to prevent spills from an accidental valve opening (e.g., sampling and blow-down lines)?
- Are fire extinguishers and a deluge or water monitor (cannon) 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 locations? How will the movement of vapors through the vapor return line to the vehicle be established and verified?

   NOTE: At any sign of safety relief valve activation, the transfer should be stopped.

• Is the off-loading procedure clear about the location and size of the liquid and vapor lines?

• If dry disconnects are used, are they locked in place by securing the arms in a closed position?

• When opening the valves on both the vent and liquid sides, will a careful check for leaks be made?

• Are flammable (combustible) gas detectors installed at strategic points to sound an alarm if a leak occurs?

• What is the pressure inside 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. Relief pressure can vary, depending on the type of vessel used by the supplier.

• After the transfer is initiated, is the operator required to stay within a certain distance of the connections until the load is completely transferred?

   NOTE: This is required by DOT for trucks. If a rail car is involved, how will it be monitored?

• How will the operator know when the vehicle is empty so that the pump can be shut down after it loses suction pressure?

• 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? What steps will be 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, depressurized, and blocked to secure the system and the delivery vehicle?

• When disconnecting the fitting, does the procedure require the use of appropriate protective gear?

• How will the hoses be secured to keep them clean and contamination-free for the next load?

• How 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 some intermodal containers have top discharge lines; establishing pump suction requires specific operating
procedures. The procedures must either utilize the pressure in the car upon arrival or provide the pressure to push the product out of the car to flood the pump suction. How will this be managed?

- Is there verification of re-sealing?
- What mechanism is in place that allows the operator to factor any learning experiences into the next off-loading experience to continuously improve performance?
Figure 4  Typical Tank Car Dome Configuration

This figure illustrates a typical configuration, and is not intended to be used as a design specification. Qualified professionals must exercise engineering judgment to establish site specifications that meet applicable requirements.

1. Straight Ball Valve  
2. Gauging Device  
3. Safety Valve 225#  
4. Eduction Pipe  
5. Support  
6. Thermowell  
7. Sample Line
Rail Cars

Propylene oxide is typically shipped in DOT 105J300 rail cars, which are rated for 300 psig. They are constructed of welded carbon steel, insulated with four inches of fiberglass, and covered by a ¹⁄₈-inch steel jacket. The jacket heads on each head are ¹⁄₂-inch thick for protection in the event of a transportation emergency.

The only piping attachments to the cars are made through a 20-inch manway nozzle on top of the center of the car. External piping and valves are protected by a metal housing with a cover that is secured with a locking pin. Sketches of the layout of these attachments are shown in Figures 4 and 5. Liquid is removed through a 2-inch valve connected to dip pipes terminating near or on the bottom of the car in a shallow sump that contains about 10 gallons of liquid. The head space vent is through a 2-inch valve with piping that terminates just below the manway flange. Both liquid and vapor lines are equipped with excess flow check valves that restrict flow to about 125 gpm, but will not function to protect against slow leaks in plant piping.

NOTE: While unloading, if flow shuts off after having started, the excess flow valve may be checking. When this occurs, shut off flow and restart slowly, transferring at a slightly lower flow than previously used.

There is also a magnetic float gauging device that measures the liquid level for the upper half of the car only. A working platform surrounds the dome and is about 12 feet 6 inches from the ground. Consider using additional fall protection devices. Cars are commonly equipped with a pressure relief safety valve that can be set as low as 75 psig.

CAUTION: Do not exceed 60 psig on the tank car, as this may cause premature relieving of the pressure relief safety valve.
Figure 5 Typical Tank Car Configuration

This figure illustrates a typical configuration, and is not intended to be used as a design specification. Qualified professionals must exercise engineering judgment to establish site specifications that meet applicable requirements.

1. Vapor Valve
2. Manway
3. Liquid Valve
4. Placard (All 4 Sides)
5. Wheel Chocks
6. Approved Ground Clamp
7. Filter
8. Pressure Control Valve
9. Pressure Safety Valve (N₂)
10. Check Valve
11. Block Valve
12. Flexible Hose Assembly with 2” NPT Connections
13. Dry Disconnect & Flexible Hose Assembly with 2” NPT Connections
14. Nitrogen High-Point Purge with Block Valve
15. Pump
16. Pressure Gauge with Diaphragm Seal
17. Approved Ground
18. CHEMTREC Emergency Number (800) 424-9300
19. Handrail
20. Hand Brake Wheel
21. Derailer
22. Pressure Gauge
23. DOT Classification No.
Figure 6  Typical Tank Car Unloading System Configuration

This figure illustrates a typical configuration, and is not intended to be used as a design specification. Qualified professionals must exercise engineering judgment to establish site specifications that meet applicable requirements.

1. Excess Flow Check Valves
2. Pressure Relief Valve
3. Tank Car Sample Valve
4. Magnetic Level Gauge
5. Rigid Pipe with Swing Joints
6. Pressure Gauge
7. Sample Points
8. Double Seal Leak Detector
9. Centrifugal Pump
10. Emergency Block Valve
11. Ground Wires
12. Indicating Ground Detector
13. High-Temperature Shutdown
14. Sprinkler System
15. Combustible Gas Detector Alarm
16. Below-Grade Grounding System
17. Grounding Clamp
Considerations for Unloading Rail Cars

Figure 6 shows a typical unloading set-up for propylene oxide.

- The site should be safely remote from traffic, general activity, and ignition sources.
- The surface should be sloped to provide drainage into a containment area for spill control.
- The rail car should be connected to a common earth ground. Interlocking grounding devices and alarms should be used with the transfer system to provide automatic shutdown if the ground is lost.
- All fixed components of the unloading system must be located outside an area that complies with the appropriate codes and standards to provide adequate physical clearance.
- All electrical equipment, including phones, radios, and intercom systems in the unloading area, should comply with the appropriate codes and standards.
- The unloading facility and the dome area of the rail car should have some form of fire protection device, such as an automatic sprinkler system. It is recommended that flammable (combustible) gas detectors are strategically placed in the general area. Dry-powder fire extinguishers should be present and a firewater monitor should be located within 40 feet of the car dome.
- Counter-balanced steel pipe and swing joints for tank car liquid and vent connections are preferred. Dedicated flexible stainless steel hoses are also acceptable. If flexible hoses are used, a storage area for the hoses should be provided that will protect them from damage and contamination. A documented hose testing program is recommended, as they are probably the most vulnerable part of the unloading system. All hoses should be pressure tested prior to each use. Emergency block valves in the liquid and vapor piping should be capable of activation from both the elevated platform and ground level. If a pump is used, provide a stop switch at the remote location.
- Eye wash and safety shower stations should be located on both the ground and platform level. Provide personal protective equipment and have appropriate tools stored nearby.
- All transfer lines should be properly identified, so that proper alignment can be made.
- To prevent rolling during unloading operations, the car’s hand brake must be set and the wheels must be chocked.
- To protect a car from other traffic on the rails during unloading, a derail device should be positioned on the track 50 feet from the end of the car being protected.
- Per DOT regulations, a warning sign (blue background with white letters) must be attached to the rail about four feet beyond the derail device. If unloading at night, a blue lantern is to be hung on the warning sign. If the track is active
from both directions, a derail device, sign, and lantern should be placed at each end of the tank car.

• All regulations, including DOT attendance requirements, must be followed. For additional safety, a person should be stationed close enough to maintain visual contact with the car during the unloading operation.

• Unloading hoses and arms should be disconnected when there is no one in attendance or when transfer is stopped.

Tamper evident seals are applied to all shipments of propylene oxide. Shippers are encouraged to apply tamper evident seals on residue rail cars returning to Dow.

General Guidelines for Unloading Rail Cars

1. Confirm that the rail car contains propylene oxide, i.e., perform a positive ID check or check shipping documentation such as the car number, the DOT placards, the car label, and other shipping documentation.

2. Per DOT regulations, place a blue caution sign (or lantern) on the track. Put a blue lantern on the flag if the job is being done at night. Put the derail device in the derailing position. Chock the wheels. Set the hand brake. Activate the barricade system and operational lights.

3. Attach the lower ground cable to the carriage support and confirm that the ground interlock is active. Extend and secure the loading rack to the top of the car. Open the dome cover and attach the upper grounding cable to the dome.

4. Check that the bulk tag correctly identifies the contents as propylene oxide. Sampling the car can confirm product identity and determine if the material is suitable for unloading (see page 20, “Sampling Equipment”).

5. Ensure that appropriate measures are taken to prevent storage tank overflow.

6. Connect the liquid and vent lines to the car. Open the bleed valves at the tank car end. Purge air from the unloading and vent lines with nitrogen and pressure the lines (maximum 60 psig). Pressure test the lines adequately, i.e., for about one minute. If the pressure does not hold, search for leaks with soap suds or other leak-detecting fluids, and correct leaks.

7. Open the vapor valve on the tank car and determine the car pressure, which may range from 10-40 psig. Confirm that the liquid and vapor valves at the storage tank are open. Equalize the pressure on the two tanks by opening the final vapor block valve at the rail car rack.

8. Open the liquid line on the rail car, at the rack, and at the pump. Start the unloading pump. Check the pump for leaks and proper operation. Tank cars may be off-loaded using nitrogen pressure of 40-50 psig in lieu of pumping.

CAUTION: Do not exceed 60 psig in the tank car, as this may cause premature relieving of the pressure relief safety valve.
9. As soon as the car is empty, stop the unloading pump. Avoid allowing the pump to run dry to prevent damage to the mechanical seal.

10. Clear the liquid unloading line into the car by purging with nitrogen. Close the liquid valve on the car and empty the liquid line from the car into the storage tank by continuing to purge with nitrogen. Close the rack liquid valves, the pump valves, and the liquid inlet valve into the tank. Close the vapor line into the tank. Adjust the nitrogen pressure in the car to the 10-15 psig range and close the vapor valve on the car and rack. Bleed down and disconnect the loading lines. Cap them and secure them to the loading ramp. Replace the plugs in the rail car valves. Secure the magnetic gauge. Remove the upper ground cable from the dome, close the dome cover, and bolt it down. Retract the loading ramp. Remove the lower ground cables from the carriage support. Remove the blue flag, blue lights, and derails. Remove the wheel chocks on the car. Leave the brake engaged for the railroad crew to release. Deactivate the barricade system.

Tamper evident seals are applied to all shipments of propylene oxide. Shippers are encouraged to apply tamper evident seals on residue rail cars returning to Dow.

**Tank Trucks**

Acceptable tank trucks to transport propylene oxide are defined in 49 CFR §173.243.

Different types of dedicated trailers are used by suppliers to transport propylene oxide in North America. Typically DOT412 or MC331-type trailers are used. Safety valve pressure settings of commonly used propylene oxide tank trucks can vary from 25-260 psig, depending on the specifications used to design and manufacture the vessel. Contact Dow for specific details.

Propylene oxide trailers are commonly equipped with a mechanical outage gauge, a dial thermometer, and a pressure gauge. All liquid and vent connections are typically located at the back, behind the rear wheels, and are typically equipped with 2-inch dry disconnect fittings.

Tank trucks are sometimes equipped with excess flow valves on the liquid line. Quick-acting lever-cable systems for remote shut-off may be accessible from different locations on the trailers. There are also terminal valves and quick-connect type plugs on the liquid and vapor connections. A bleed valve for blow-down is connected to a tee between the inside valve and the terminal block valve.

Trailers may not be loaded completely full because they must comply with maximum load restrictions determined by state and federal regulations. Prior to loading, the trailer is purged with nitrogen. After loading, a residual nitrogen blanket in the range of 25-30 psig will be left on the trailer.

**Considerations for Unloading Tank Trucks**

- The site should be safely remote from traffic, general activity, and ignition sources.
• Consider the use of road barricades and warning lights to restrict traffic or other operations from the unloading area.

• The surface should be sloped to provide drainage into a containment area for spill control.

• The tank truck should be properly electrically grounded. Interlocking grounding devices and alarms should be used with the transfer system to provide automatic shutdown if the ground is lost.

• All electrical equipment, including phones, radios, and intercom systems in the unloading area, should comply with the appropriate codes.

• The unloading facility and the rear area of the truck should have some form of fire protection devices, such as an automatic sprinkler system. It is recommended that combustible gas detectors are strategically placed in the general area. Dry-powder fire extinguishers should be present and a firewater monitor should be located within 40 feet of the trailer.

• Truck unloading can be done by either pumping or applying nitrogen pressure to the truck. The advantages and disadvantages of each method of transferring product should be reviewed to make certain all safety and environmental questions are answered.

NOTE: To minimize personnel exposure to propylene oxide, Dow encourages customers to use a dedicated hose permanently attached to the pumping system. For this reason, Dow does not supply hoses or truck pumps.

• Steel pipe and swing joints for truck liquid and vent connections are preferred. Dedicated flexible stainless steel hoses are also acceptable. If flexible hoses are used, a storage area for the hoses should be provided that will protect them from damage and contamination. A documented hose testing program is recommended, as they are probably the most vulnerable part of the unloading system. All hoses should be pressure tested prior to each use. Emergency block valves in the liquid and vapor piping should be capable of activation from both the elevated platform and ground level.

• Eye wash and safety shower stations should be located on both the ground and platform levels. Provide personal protective equipment and have appropriate tools stored nearby.

• All transfer lines should be properly identified, so that proper alignment can be made.

• All regulations, including DOT attendance requirements, must be followed. An attendant must be stationed close enough to maintain visual contact with the truck during the unloading operation.

• Unloading hoses and arms should be disconnected when there is no one in attendance or when transfer is stopped.
General Procedures for Unloading Tank Trucks

1. Make sure the unit is spotted correctly and that its wheels are chocked, its brakes are set, and the road barricades are up. Turn on the flashing lights or other visual warning systems at the road entrance.

2. Place a placard on the windshield or steering wheel of the truck to warn against moving the vehicle, or remove the keys and place in a secure area. Direct the driver to wait in a designated area. The driver should not remain in the cab.

3. Attach the lower ground cable to the carriage support and confirm that ground interlock is active.

4. Confirm that the rail car contains propylene oxide, i.e., check the car number, the DOT placards, the car label, and shipping documentation. Sampling the car can confirm product identity and determine if the material is suitable for unloading (see page 20, “Sampling Equipment”).

5. Ensure that appropriate measures are taken to prevent storage tank overflow.

6. Connect the unloading line to the truck liquid line.

7. Connect the vent-back (vapor) line to the truck.

8. Purge the unloading and vent-back lines with nitrogen and pressure up to 60 psig to conduct a pressure check. Isolate the unloading lines with appropriate block valves and observe the pressure for about one minute. If the pressure does not hold, search for leaks with soap suds or an equivalent leak detecting liquid and make necessary repairs.

   CAUTION: Some trailers are designed for lower pressures.

9. Confirm that the vent and liquid inlet valves at the storage tank are open. Slowly equalize the pressure on the truck and the vapor line to the truck.

10. Open the valves in the liquid line on the tank truck, at the emergency block valve at the pump suction, and discharge. Check for leaks and proper operation.

11. If pressuring off the propylene oxide with nitrogen, make certain that the nitrogen is dry and contains less than 2% oxygen. Then open the tank vent line to an appropriate scrubber and pressure the truck with nitrogen. Open the liquid line to begin the transfer.

   CAUTION: Low-pressure trucks may not be suitable for pressure off-loading. Provide provisions to ensure that the tank truck is protected against vacuum to prevent collapsing the cargo tank during the unloading operation.

12. As soon as the trailer is empty, stop the unloading pump. Avoid allowing the pump to run dry to prevent damage to the mechanical seal.

13. Clear the liquid unloading line into the truck by purging with nitrogen. Close the liquid valve on the truck and empty the liquid line from the truck into the...
storage tank by continuing to purge with nitrogen. Close the pump valves, the emergency block valves, and the liquid inlet valve into the tank. Close the vapor line into the tank. Adjust the nitrogen pressure in the car to the 10-15 psig range and close the vapor valve on the tank and at the load rack. Bleed down and disconnect the loading lines. Cap and secure the hoses. Place caps on truck piping. Hoses need to be stored in a secure location. Remove the upper ground cables. Check the trailer DOT placards to see that they are properly affixed and in good condition. Remove the wheel chocks, take down the barricade, turn off the visual warning system, and release the truck to the driver.

ISO Containers
Acceptable portable containers used to transport propylene oxide are defined in 49 CFR §173.243.

Propylene oxide is shipped in other types of containers, such as IM101 and IM105 portable tanks, which contain approximately 4,000-6,000 gallons of product, shipped under a nitrogen blanket of between 15-30 psig. Unloading valves are typically located at the rear of the tank (see Figure 7).

ISO Tank Shipments and Unloading Guidelines
The ISO tank shipments and unloading procedures are similar to the tank truck procedures located on page 48, “Tank Trucks.”

Material and/or Container Return Guidelines
Always contact Dow if there is reason to suspect the product has been tampered with or damaged while en route to your facility.

For safety and security reasons, DO NOT RETURN THE PRODUCT WITHOUT PRIOR CONSULTATION WITH AND APPROVAL from Dow.
Figure 7 Typical IMO Tank Configuration

This figure illustrates a typical configuration, and is not intended to be used as a design specification. Qualified professionals must exercise engineering judgment to establish site specifications that meet applicable requirements.

1. Tank Frame
2. Tank Shell In Stainless Steel with Insulation and Aluminum Cladding Protection
3. Male Bottom Discharge
4. Data Plate
5. Ladder
6. Walkway
7. Steam Heating (Not Used for P.O. Service)
8. Thermometer
9. Safety Relief Valves (2) with Tank
10. Manhole
11. Nitrogen Inlet
12. Provision For Filling/Drain System
13. Ball Valve
14. Flexible Hose Assembly
15. Block Valve
16. Check Valve
17. Pressure Relief Valve
18. Pressure Control Valve
19. Filter
20. Pump
21. Pressure Gauge with Diaphragm Seal
22. Ground Wire
23. Flexible Hose Assembly
24. DOT Classification Number
25. Pressure Gauge
26. DOT Placard (All 4 Sides)
27. CHEMTREC Emergency Number (800) 424-9300
28. Carrier’s Name

Container Owner/Lessor’s Name
Certification Decals

![Diagram of IMO Tank Configuration](image-url)
Employees must be sensitive to their work environment and able to recognize normal and suspicious activities, unusual behaviors, as well as any container abnormality. Employees must also be able to implement an action plan or notification sequence. Possible threats may include fraudulent or intentionally false statements to initiate a shipment of propylene oxide. Possible threats to the container in transportation or storage/tank car must also be taken into account. A plan is important to prevent unauthorized access to propylene oxide containers at every point in the supply chain and to ensure careful monitoring of the movement and reporting of overdue or out-of-route shipments to supervisors, shipping companies, and appropriate law enforcement agencies.

Additionally, using cable seals to secure the loading or unloading fittings during transit is strongly recommended. Personnel responsible for loading, transporting, and unloading propylene oxide should be trained to recognize and report tampering with the containers, when seals are missing, or when seals have a different number than indicated on the loading documents.

The elements of the plan should, therefore, address:

- Ensuring fulfillment only of legitimate orders
- Access to storage areas
- Sealing containers and recognition of compromised seals
The following regulatory information concerning propylene oxide is not necessarily a complete list of all applicable laws and regulations, but is intended for consideration only (not as legal advice) and is believed to be current on the date this manual was published. It is your responsibility to investigate and comply with the regulations in your locality, state, province, and/or country. Consult regulations periodically for other applicable regulations, changes, and updates.

**National Fire Protection Association (NFPA)**

Hazard Ratings: health 3, flammability 4, reactivity/instability 2.

**Section 8(a) Toxic Substances Control Act (TSCA)**

Reporting requirements established for persons who manufacture, import, or process.

**Section 311 Clean Water Act**

Spillage in navigable waters is regulated by the procedures established by this provision.

**Section 111 Clean Air Act**

Propylene oxide is identified as a potential human health hazard for which specific control technologies are prescribed.

**Section 112 Clean Air Act**

Propylene oxide is identified as a Hazardous Air Pollutant.

**Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA)**

A propylene oxide release equal to or exceeding the reportable quantity (RQ) prescribed must be reported immediately (RQ in pounds = 100).

**Section 302 Superfund Amendments and Reauthorization Act (SARA)**

Emergency planning and notification requirements are applicable if more than the Threshold Planning Quantity (TPQ) of any extremely hazardous substance is present in a facility. The TPQ is established at 10,000 pounds.

**Section 311 and 312 Superfund Amendments and Reauthorization Act (SARA)**

The “Hazard Categories” established for Community Right-to-Know reporting requirements are: immediate health hazard, delayed health hazard, fire hazard, reactive and sudden release of pressure.

**Section 313 Emergency Planning and Community Right-to-Know Acts of 1986**

Annual reporting of releases to the environment required.

**American Conference of Governmental Industrial Hygienists (ACGIH)**

A Threshold Limit Value-Time Weighted Average (TLV-TWA) of 2 ppm has been adopted for propylene oxide.
National Toxicology Program (NTP)
Propylene oxide is listed in NTP’s Report of Carcinogens.

International Agency for Research on Cancer (IARC)
IARC evaluated propylene oxide and concluded that there is sufficient evidence of carcinogenicity in experimental animals to list as an animal carcinogen, category 2B (possible human carcinogen).

Department of Transportation (DOT)
The DOT Hazardous Material Table identifies propylene oxide as a flammable liquid and hazardous substance.

Proper Shipping Name: Propylene Oxide
UN Number: 1280
R. L. Rowley, W. V. Wilding, J. L. Oscarson, 
Y. Yang, N. A. Zundel, T. E. Daubert, 
R. P. Danner, DIPPR® Data Compilation 
of Pure Chemicals Properties, Design 
Institute for Physical Properties, AIChE, 
For current contact information for propylene oxide.
The Americas (except Brazil and Mexico)
1-800-447-4369
1-989-832-1542

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