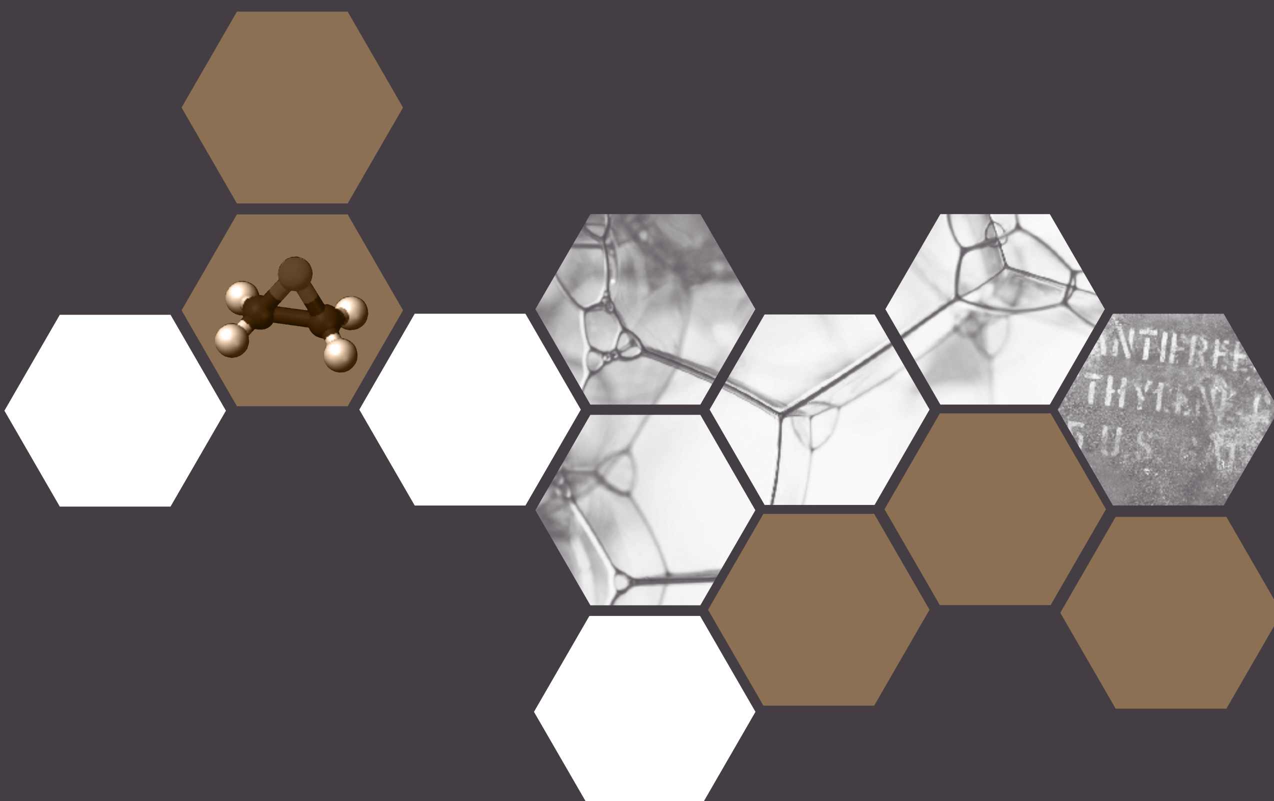
ethyleneoxide

third edition



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To the Reader

Manual Preparation

As members and affiliated companies of the American Chemistry Council, we support efforts to improve the industry's responsible management of chemicals. To assist in this effort, the American Chemistry Council's Ethylene Oxide/Ethylene Glycols Panel supported the creation and publication of this manual. The Panel is comprised of the following companies:

Balchem Corporation/ARC Specialty Products

BASF Corporation

Bayer Material Science LLC

Celanese Ltd.

Champion Technologies

Croda, Inc.

The Dow Chemical Company

Eastman Chemical Company

Honeywell

Shell Chemical LP

The development of this manual was led by the Panel's Ethylene Oxide Safety Task Group (EOSTG), a group comprised of producers and users of ethylene oxide. The EOSTG functions to generate, collect, evaluate and share information to support product stewardship with regard to ethylene oxide. The EOSTG formed a manual work group, chaired by Keith Vogel of Lyondell Chemical Company, to lead the development of this document. The following work group members provided significant contributions:

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Appendix C Railcar Repressurization

This Appendix C contains additional discussion on considerations for pressurizing EO Railcars supplementing the primary discussion in Chapter 9.

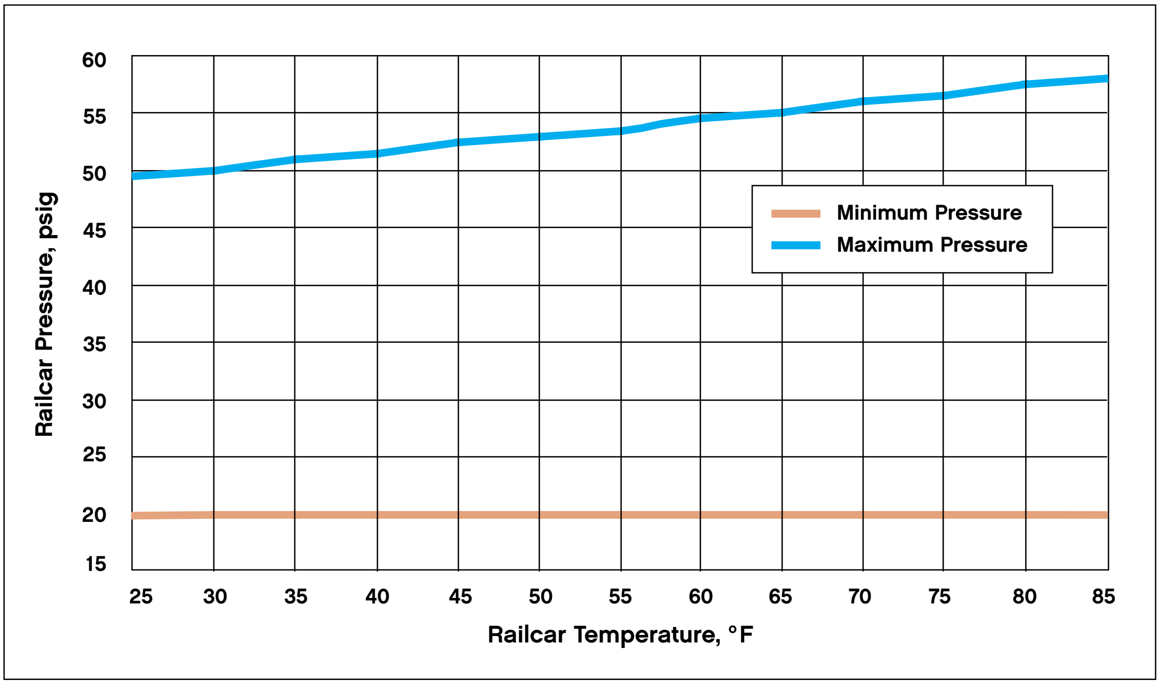
Follow federal regulatory requirements and criteria EO supplier guidelines for pressurizing railcars. Chapter 9 of this Manual and this supplemental discussion offer additional considerations for pressurization.

The guidelines discussed here are intended to maintain an inert atmosphere within the railcar up to a temperature of 105°F (DOT requirement), while maintaining the railcar pressure below the setpoint of the pressure safety valve.

Note that the use of Figure 6.16 is inappropriate for pressurizing railcars in EO service as the temperature in the railcar changes in transit. That particular Figure applies to EO storage facilities where either storage temperature and/or pressure can be continuously monitored and controlled to maintain the vapor space in the inert, non-decomposable region.

- Railcars utilized for the transportation of bulk quantities of EO must be pressurized with an inert gas to maintain the vapor contents in a safe, non-combustible, non-decomposable state up to a temperature of 105° F (41°C). This is a requirement specified by the US Department of Transportation as found in 49 CFR, Chapter 1, Part 173.323(f). To provide an inert vapor space in an EO railcar, either (a) pure nitrogen or (b) storage tank vapors composed primarily of nitrogen (from an unloading practice typically referred to as vapor balancing) are most often used.
- The requirement for maintaining an inert, non-combustible, non-decomposable vapor space applies to both "full" and "unloaded" EO railcars. An unloaded railcar contains residual amounts of EO liquid that cannot be completely discharged into a receiving storage tank or vessel. Consequently, a potentially hazardous condition could be created if the railcar vapor space is not properly inerted.
- Railcars used for the transportation of bulk quantities of EO are designed to leave minimal volumes of residual liquid (e.g., < 50 gallons) after the cargo is discharged. This assumes many factors, such as (a) the railcar internals are in good repair; (b) the rail siding is level, thereby not allowing an accumulation of liquid ("ponding") at either end of the railcar; and (c) the cargo is unloaded to the maximum extent possible (e.g., not terminating the discharge of EO from the railcar before the unloading pump loses suction, or before nitrogen begins to blow through the liquid unloading line). The railcar pressurization information provided in Chapter 9 and this Appendix C is intended only for those situations where no more than 50 gallons of liquid EO remain in the railcar following unloading.
- The gas selected to provide an inert atmosphere within the vapor space of the railcar must not be reactive with EO, or contain any contaminants that might be reactive with EO. The availability and inertness of nitrogen mean that it is frequently used for pressurizing railcars to provide a non-combustible, non-decomposable vapor space. Nitrogen can be used as (a) pure gas, or (b) the major component of displaced vapors from an EO storage tank. Contact your EO supplier if a gas other than nitrogen is to be used to inert an EO railcar.
- While sufficient pressure must be applied to render the vapor space inert up to 105°F , applying an excessive level of pressure could result in the railcar safety valve relieving at temperatures below 105°F, releasing EO vapors into the environment and depleting the inventory of nitrogen in the railcar. The temperature and pressure of a railcar are not constant and are influenced by many factors such as sun exposure and ambient air temperature. As a railcar increases in temperature, additional EO from any remaining liquid heel will evaporate, increasing both the concentration of EO in the vapor space and the pressure within the railcar. The ranges of pressures outlined in Chapter 9 have been established to provide for:
  - an inert, non-combustible, non-decomposable vapor space up to 105°F, and
  - remaining at or below the 75 psig safety valve set pressure at 105°F.

Figure C1 Unloaded Railcar Repressuring — Nitrogen — Less than 50 Gallon EO Heel



Nitrogen Padding

Pure nitrogen is frequently used both to (a) pressure out liquid EO from railcars into storage vessels, and (b) pressurize the unloaded railcar for the return trip to the EO supplier.

The composition of the railcar vapor space, and accompanying temperature and pressure, determine whether the vapor space is inert and non-decomposable. The composition of the vapor space is influenced by the volume of the EO heel remaining in the railcar, and the nitrogen pressure applied to the railcar after unloading. Generally speaking, the larger the quantity of liquid EO heel, the greater the quantity of EO that can evaporate within the railcar. If an insufficient volume of nitrogen is injected into the railcar (using pressure as an indirect measure of nitrogen volume), the vapor space may not remain inert as additional EO evaporates from the remaining liquid heel. Conversely, injecting too much nitrogen upon initial pressurization could lead to a later discharge from the pressure safety valve.

Although pure nitrogen may be injected into the railcar during or immediately after unloading, some EO will evaporate into the vapor space during the time interval required to discharge the contents of the railcar. As a consequence, immediately after the railcar is unloaded, repressured, and secured for return to the supplier, the vapor space will also contain some finite quantity of EO in addition to the nitrogen that was injected into the railcar. How much EO evaporates into the vapor space during the unloading process is dependent on both the length of time required to unload the railcar, and the temperature of the railcar.

- The minimum pressure levels illustrated in the section of Chapter 9 titled “Inerting the Unloaded Railcar for Return” accommodate the evaporation of EO into the nitrogen during the unloading and repressuring process. The Table provided assumes that at the completion of the unloading process, the partial pressure of the EO in the vapor space is no less than 21% of the vapor pressure of EO at the temperature of the railcar.
- The minimum repressure levels discussed within these guidelines are intended to account for:

  (a) possible errors in the measured railcar temperatures and pressures, and

  (b) uncertainties in the predicted physical and chemical characteristics of EO used to develop these guidelines

- The Tables set out in Chapter 9 (9.1, 9,2) are intended to guide the user to calculate minimum and maximum pressure levels for an unloaded railcar with an initial heel of less than 50 gallons of EO. Figure C1 is a graphical representation.

Vapor Balancing

This discussion assumes the EO tank from which the balancing vapors originate is padded with nitrogen. Contact your EO supplier if vapor balancing is utilized, and nitrogen is not used as the inerting gas for the EO storage vessel.

Unloading EO from railcars into storage facilities using vapor balancing is frequently practiced. EO that is unloaded and directed into a tank or receiving vessel displaces vapor from that storage vessel. This same vapor is then redirected back to the railcar.

Unlike the nitrogen vapors that result from pressuring unloaded EO railcars with pure nitrogen, the vapors displaced and originating from EO storage tanks are mixtures of nitrogen and EO. Higher EO storage tank temperatures will result in a higher percentage of EO and a lower quantity of nitrogen in the tank vapors. As a consequence, determining the appropriate level of pressurization for empty railcars when utilizing vapor balancing is a more complex process.

Depending on the temperature of the railcar, and the composition of the vapors displaced from the receiving storage tank into the railcar, some additional EO could evaporate into the vapor space during the unloading process. How much, if any, additional EO evaporates into the railcar vapor space is directly influenced by (a) the composition of the blanketing vapor displaced from storage tankage, (b) the temperature of the railcar, and (c) duration of time required to unload the railcar.

The minimum pressure levels illustrated in Chapter 9 are intended to accommodate the potential for additional EO to enter the vapor space of the railcar during the unloading and repressuring process. The illustrations assume that immediately after the railcar is unloaded, repressured, and secured for return to the supplier, the vapor space of the railcar has an EO content corresponding to either (a) the composition of the vapors balancing vapors displaced from the EO storage vessel, or (b) a composition corresponding to an EO partial pressure of no less than 21% of the vapor pressure of EO at the temperature of the railcar, whichever of the two represents the greater concentration of EO.

- The minimum repressure levels within the guidelines is intended to account for:

  (a) Possible errors in the measured railcar/ storage tank temperatures and pressures, and

  (b) Uncertainties in the predicted physical and chemical characteristics of EO utilized in the development of these guidelines.

The illustrations in Chapter 9 set out examples of minimum and maximum repressure levels for an unloaded railcar when using vapor balancing. These illustrations are applicable only for circumstances where an initial EO heel exists of no greater than 50 gallons. The following Figure C2 is a graphical representation.

Figure C2 Unloaded Railcar Repressuring — Vapor Balancing — Less than 50 Gallon Heel