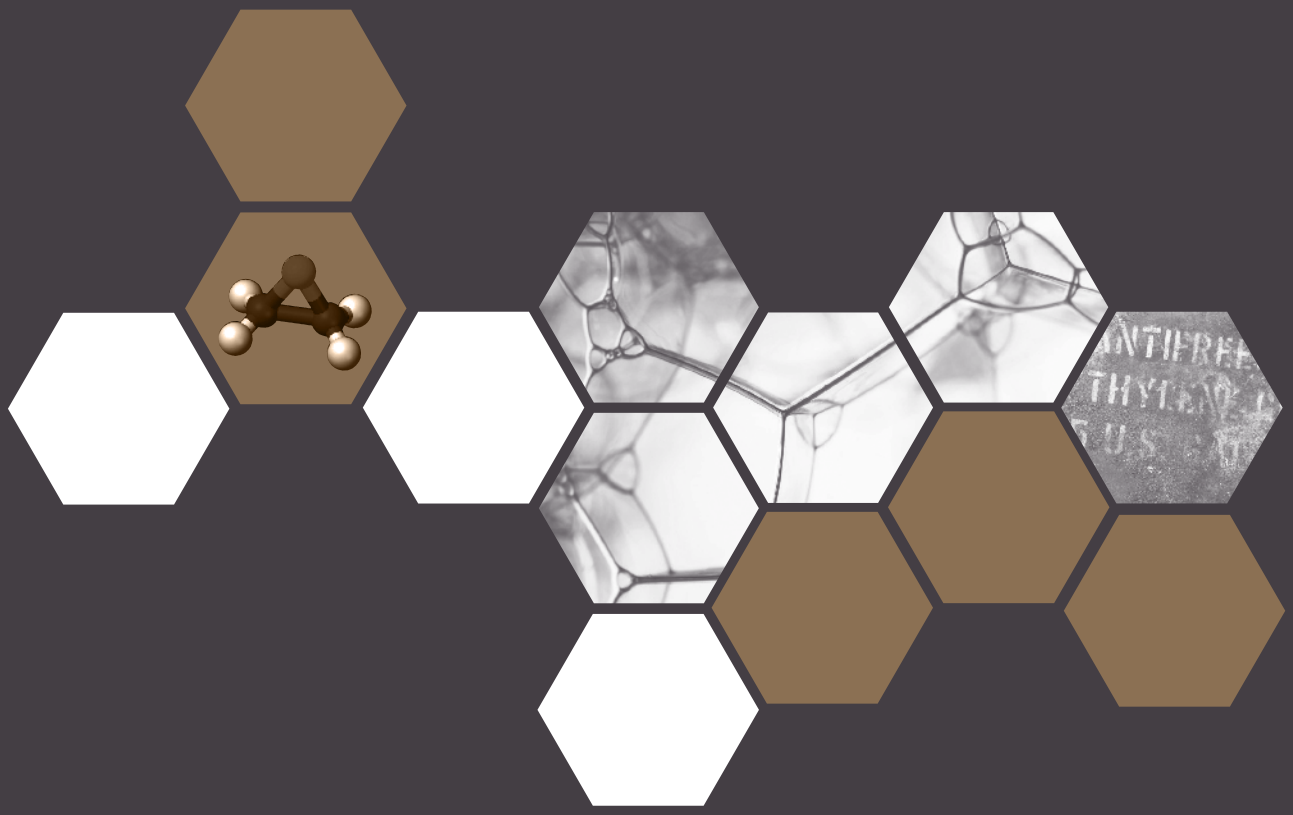
ethyleneoxide

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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Gerald Wise	Shell Chemical LP

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Ralph Gingell	Shell Chemical LP
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Karl Loos	Shell Chemical LP
David McCready	The Dow Chemical Company
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Table of Contents

Figures

Tables

9.0 Transportation and Unloading Operations

9.1 Introduction

This Chapter provides a basic overview of transportation and unloading operations for EO.

Note that the use of dedicated EO unloading facilities is extremely important to help avoid contamination of EO with other chemicals.

9.2 Emergency Response Telephone Numbers

In the event of an emergency involving an EO shipment, contact the emergency response telephone number found on the shipping papers or the emergency assistance numbers provided in the shipper's MSDS. CHEMTREC® (Chemical Transportation Emergency Center) was established as a public service hotline for fire fighters, law enforcement personnel, and other emergency responders to obtain information and technical assistance for emergency incidents involving chemicals and hazardous materials. CHEMTREC provides a 24-hour emergency telephone number on shipping documents that can be called in the event of an emergency involving hazardous materials.

For additional assistance or information within the United States call CHEMTREC: (800) 424-9300 or (202) 483-7616.

For additional assistance or information within Canada, call: CANUTEC at (613) 996-6666, collect (or *666 via cellular phone within Canada). For additional information regarding shipment to and from Canada see Section 9.8.

9.3 Ethylene Oxide Classification

EO is classified by the U.S. Department of Transportation (DOT) as a primary poison gas hazard (Division 2.3) with a subsidiary hazard of a flammable gas (Division 2.1), and must be placarded accordingly. Further, it carries the materials poisonous by inhalation (PIH) designation by the DOT. See also Chapter 11, Selected Regulations.

9.4 Railcars

Design – General

DOT requires that EO be transported in Class 105-J tank cars. All tank cars used in EO service must have a tank pressure rating of at least 300 psig by July 1, 2006, at the latest. Most EO tank cars in service already meet this requirement.

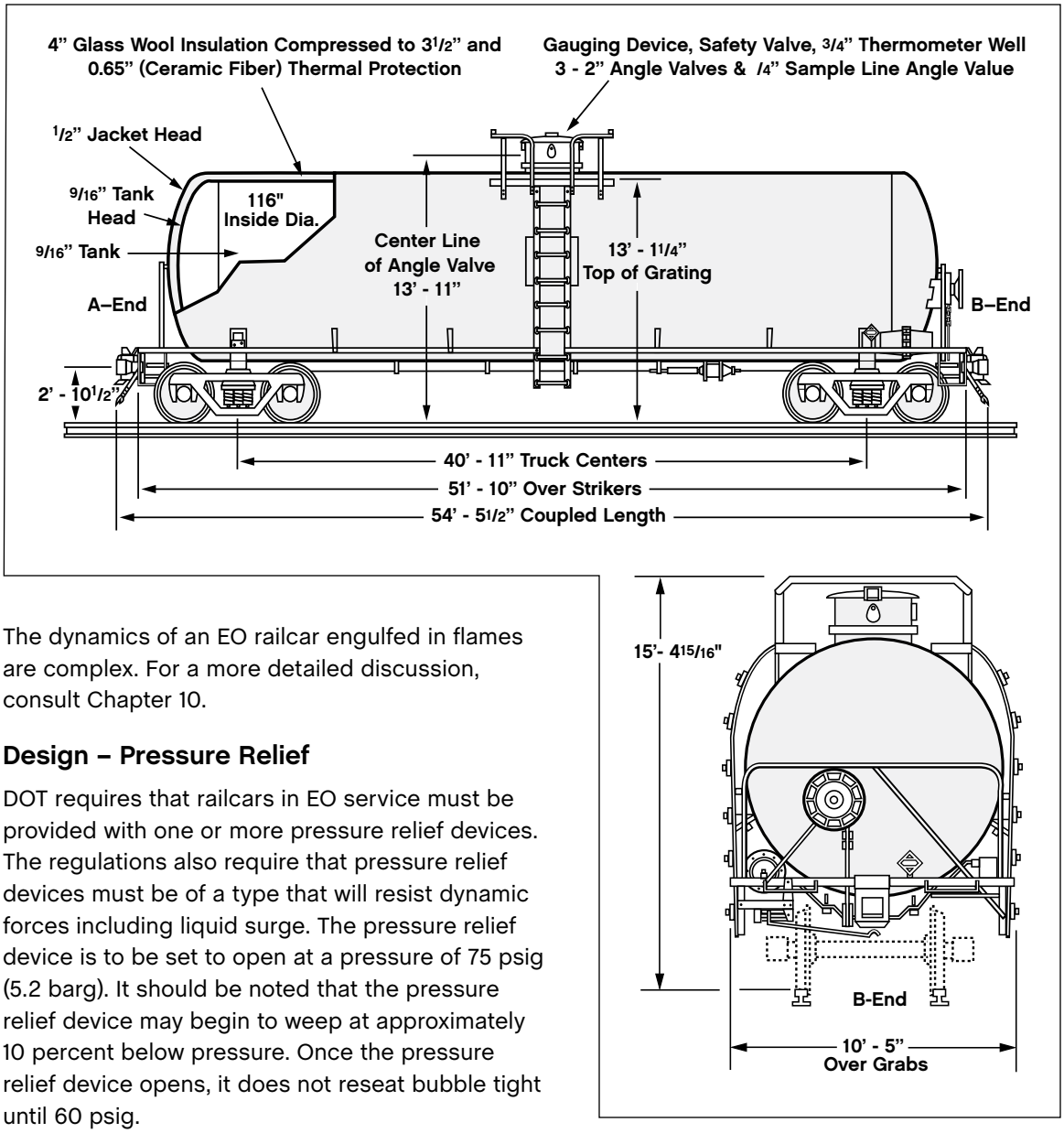
Regulations also require EO tank cars to have a reclosing pressure relief device set to function at 75 psig. These requirements are specified in 49 CFR 173.323. DOT class 105-J railcars meeting the required 300 psi tank test pressure are constructed from fusion welded carbon steel with 9/16" minimum plate thickness, and must have an approved thermal protection system.

An EO tank car is designed for loading and unloading from the top only with no bottom fittings. The potential for leakage from damaged tank fittings is greatly reduced in a transportation incident when protected top fittings and no bottom fittings are used. An EO railcar (Type DOT 105-J) is equipped with two eduction pipes/unloading connections, one vent for loading or vapor connection, a gauging device, a reclosing pressure relief device (safety valve), and a thermometer well (thermowell). All railcars are equipped with a sump for the eductor or discharge tubes. Some railcar tank bottoms are designed to slope towards the sump. The sump aids in minimizing the remaining EO heel after the railcar is unloaded.

Design – Insulation

A typical insulation system found for an EO railcar consists of 0.65 inches of ceramic fiber surrounding the tank shell, covered with 4-inches of glasswool fiberglass insulation compressed to 3-1/2 inches by an outer metal jacket. The ceramic fiber section also provides additional protection to prevent an external fire from raising the temperature of the tank metal to a point at which it loses strength. The outer metal jacket is 11 gauge (about 1/8 -inch) carbon steel, except at the ends of the car where tank puncture resistance is provided by 1/2 -inch headshields. Such insulation systems have been used for EO railcars for a number of years and are credited as a major factor in the record of transportation safety achieved by this product.

Figure 9.1 DOT 105-J railcar for transporting Ethylene Oxide



The dynamics of an EO railcar engulfed in flames are complex. For a more detailed discussion, consult Chapter 10.

Design – Pressure Relief

DOT requires that railcars in EO service must be provided with one or more pressure relief devices. The regulations also require that pressure relief devices must be of a type that will resist dynamic forces including liquid surge. The pressure relief device is to be set to open at a pressure of 75 psig (5.2 barg). It should be noted that the pressure relief device may begin to weep at approximately 10 percent below pressure. Once the pressure relief device opens, it does not reseat bubble tight until 60 psig.

Design – Excess Flow Check Valves

EO tanks are equipped with float type excess flow check valves underneath each liquid load/unload valve and vapor valve. This is a safety precaution as the valve is designed to shut off the flow of liquid or vapor if the valves are "sheared" from the cars pressure plate during an accident. An excess flow valve is not designed to, and will not, shut off flow in the event of minor or slow leaks from valves, hoses, or flanges.

If a liquid or vapor valve is opened too rapidly or if an excessive unloading rate occurs, the excess flow check valve may close, cutting off the flow of liquid or vapor prior to its design shut off flow of 120 gpm. If the excess flow check valve closes, the pressure needs to be equalized to force the internal plug back to the open position. Equalizing the pressure can be performed by closing the load/unload valve on the liquid line. In extremely unusual circumstances, the vapor valve can get stuck closed if there is EO polymer present in the vent line. Nitrogen pressure may have to be supplied on the downstream side to force the internal plug in the valve back to the open position.

Be aware that the vapor line excess flow check valve can close if the car is depressurized too

Figure 9.2 Dome Arrangement of a DOT 105-J Railcar for Ethylene Oxide Service

rapidly. If the excess flow check valve closes, a false reading of railcar pressure can occur, as pressure is measured in the line downstream of the car loading/unloading valve.

If the excess flow check valve has inadvertently closed, the railcar could be mistakenly over-pressured and lift the pressure relief device set at 75 psig. Again, by closing the load/unload valve, the pressure can equalize on both sides of the excess flow check valve and gravity should drop the float back into position.

Significant problems experienced with loading and unloading operations such as malfunctioning equipment, running gear, or loading appliances should be reported to the EO supplier. Other than emergencies, repairs should only be performed with supplier approval in order to maintain material quality, equipment function, and design requirements. Emergency repairs should be reported to the supplier before putting the car in transportation.

Preparation for Unloading

Persons unloading a railcar or offering an unloaded railcar for transportation have had general training with respect to general safety awareness and railcar operation; function-specific requirements; and safety/emergency response. 49 CFR 172.704 requires refresher training at intervals (at least every 3 years).

Remember that EO in a railcar is constantly maintained under an atmosphere of an oxygen-free, inert gas. Air (oxygen) is not allowed to enter railcars or other transportation containers when in EO service, whether filled or unloaded. A vapor environment with an oxygen level of less than 1% has been generally considered “oxygen-free.”

Dry nitrogen has been successfully and widely utilized as an inerting gas for railcars and other transportation containers. It has limited solubility in liquid EO.

CAUTION:

Carbon dioxide is generally not considered suitable as an inerting gas for railcars and other transportation containers. CO2 exhibits very high solubility in liquid EO (approximately ten times that of nitrogen), allowing the cargo (or heel) of EO to absorb a significant quantity of carbon dioxide from the railcar vapor space. This inherent property of CO2 to readily dissolve into EO can result in a sizeable depression of both the CO2 partial pressure and total pressure within the void space of a railcar. As a consequence, the pressure within the railcar could fall precipitously to a sufficiently low level to be rendered non-inert, and susceptible to hazardous decomposition reactions.

Other general considerations include:

- EO is highly reactive.
- The use of dedicated EO unloading facilities is extremely important to help avoid contamination of EO with other chemicals.
- The unloading area should be well ventilated and away from sources of ignition.
- OSHA requires that exposures not exceed either 1 ppm averaged for an 8-hour period or 5 ppm over a 15 minute period (excursion level).
- Use appropriate respiratory protection (see Section 7.5) when making/breaking connections, and during EO product sampling.
- Know where safety showers and eye wash facilities are located in the railcar unloading area.
- Know the location, in the unloading area, of fire fighting equipment (extinguishers, fire monitors, hose reels, deluge systems) and know how to use these.

- Consider checking or replacing any fire extinguishers with broken seals before commencing unloading.

It can be useful to develop and provide to unloading personnel a detailed site-specific procedure and checklist specifying each step of the unloading operation and the precautions to be observed. Consider maintaining an operator unloading log to record key information for both the railcar and the receiving storage tank or vessel, such as:

- Railcar and storage vessel temperature
- Railcar and storage vessel pressure
- Storage vessel level
- Railcar numbers
- Seal numbers

Consider recording and monitoring the temperature of EO railcars from time of arrival on-site up through railcar unloading. The presence of higher than normal temperature or a temperature rise not explained by ambient conditions may indicate the presence of contamination and the potential for reaction in the railcar. Consider maintaining records of all previous cars received at that site to understand the normal temperature of EO. See Chapter 5 for a discussion of the hazards of contamination and Chapter 10 for emergency response.

DOT requires that the DOT car specification number on the car must be 105-J300W. “Ethylene Oxide” and “Inhalation Hazard” must be stenciled on opposing sides of the railcar. Check the dome for an intact seal. If the seal is not intact, check for signs of tampering and monitor railcar temperature and verify as stable before unloading. Notify the EO supplier if the seal is not intact.

If the temperature is not stable or contamination is suspected, initiate emergency procedures as described in Chapter 10 of this manual.

Typical steps for unloading EO follow, along with a series of photographic illustrations.

The DOT requires placement of blue signs that read “Stop — Tank Car Connected” or “Stop — Men at Work” at appropriate spots.

Figure 9.3 DOT “Stop—Tank Car Connected” Sign

- Locking track switches and utilizing a derail mechanism to prevent collisions with other cars.

Typical steps for unloading (photographic illustrations);

- Setting the hand brake (DOT requirement).

- Chocking the car front and back of at least one wheel (DOT requirement).

- Grounding the railcar on its bolster or on the top working area. Because corrosion between bolted and riveted parts on railcars can serve as insulators between the ground clamp and the tank, continuous continuity checks are helpful when grounding the railcar as shown in the photo above. Regardless of where the grounding clamp is applied, maintain metal-to-metal contact between the clamp and the selected railcar hardware.

- Raising the dome cover. Note how the personnel are inspecting the area under the dome carefully - use caution, as valves and devices under the dome could leak.

- Measuring and recording the temperature of the EO in the railcar by lowering a thermocouple or thermometer into the thermowell (allow several minutes for the temperature measurement to stabilize).

Figure 9.4 Canister Mask with Ethylene Oxide-Specific Canister

Figure 9.5 Positive Pressure "Hoseline" Type Respirator

Experience has shown that it is difficult to meet the 1 ppm exposure limit when connecting or disconnecting EO railcars. If the 1ppm exposure limit is not met, OSHA-compliant respiratory protection is available for operator use when making or breaking connections on EO railcars. Supplied air breathing devices exist for both normal operations/maintenance activities and emergencies. Check with manufacturer for details..

Unloading

Typical steps for the transfer/unloading of the EO from the railcar to the receiving storage vessel are noted here. The sequence of procedures or procedures used may vary by company; the steps provided here are for illustration purposes only.

- Wear proper PPE. Experience has shown that it is difficult to meet the 1 ppm exposure limit when connecting or disconnecting EO railcars. If the 1ppm exposure limit is not met, operators should wear OSHA compliant respiratory protection when making or breaking connections on EO railcars. Supplied air breathing devices are suitable for both normal operation/maintenance activities and emergencies. Canister masks are generally protective for limited concentration levels. Check with manufacturer for details.
- Check the valves, flanges and relief device in the dome for leaks. Leak detection procedures that are commonly practiced include use of a soap solution and detection with monitoring devices (flammable gas detectors or EO-specific detectors). A leak could result in several hazards:
  - Reduction of the pressure within a railcar resulting in a vapor space that is not inert. Additional nitrogen injection into the railcar will restore the inert atmosphere.
  - Presence of flammable vapors around the railcar.
  - Potential for exposure above OSHA levels.

  (Note: in addition to flammable vapor around the leak, railcar leaks could result in a railcar vapor space that is not inert, requiring additional nitrogen injection into the railcar to restore the inert atmosphere.)

Typical steps for the transfer/unloading of the EO from the railcar to the receiving storage vessel.

- Remove plugs in both vapor and liquid valves.

- Insert pipe extensions into the valves so that connections can be made outside the dome of the car. Be sure that pipe extensions do not interfere with operation at the valve operating mechanism.

- Attach the unloading line to the liquid valve extension.
- Off-loading can be accomplished by either pressuring or pumping EO from the railcar. In either case, (a) nitrogen and/or (b) vapors displaced from the tank receiving the EO are needed to replace the liquid and to maintain railcar pressure.
- Check for leaks on hose connections prior to introducing EO.
- Either (a) attach nitrogen, or (b) line up the vapor balance return line to the railcar vapor line to provide for maintenance of the railcar nitrogen pad.

- Purge lines with nitrogen to remove any air that might be present.
- Install a pressure gauge on the vapor line. Measure and record pressure. Refer to Figure 6.16 in Chapter 6 (Design of Facilities) for guidance on selecting proper nitrogen pressure to maintain a non-explosive EO vapor content while unloading EO.
- Monitor temperature and pressure throughout the unloading process.

- Carefully open the vent and liquid valves. If utilizing a pump to unload the EO, check the unloading pump to prevent deadheaded or vapor-bound operation.

- If sampling is part of the procedure, sample and obtain laboratory verification before unloading the railcar. Grounding of the sample cylinder is recommended to prevent static sparks.

  NOTE: Polymer has a tendency to build up in the railcar sampling line in cars equipped with a sampling valve. Sampling from the offloading line reduces potential for plugging.

- Maintain the railcar pressure in non-explosive region during unloading by adding either (a) nitrogen or (b) displaced vapors from the receiving vessel via the railcar vapor line as the inventory of EO in the railcar is depleted.

Minimizing the heel remaining in an EO railcar after unloading is a very important consideration when developing unloading procedures.

Unloading procedures that utilize vapor balancing typically employ pumps to transfer EO from the railcar to the storage vessel. Such facilities and procedures should be designed to prevent a premature stop in the unloading process, possibly resulting in a large heel of EO remaining in the railcar. Unloading practices might include blowing vapor through the railcar and losing liquid flow from a pump as a method of minimizing remaining liquid heel. However, operating a pump without flow for any duration of time could result in an EO vapor decomposition. Refer to Section 6.7 on piping and pumps for more information.

Detecting the loss of liquid flow can be achieved by such means as a flow switch or ultrasonic device in the liquid line. In some cases, the use of a properly designed sight glass (e.g. “bullseye”) may be appropriate.

The excess flow check device consists of a float that becomes buoyant at high flow. Once closed, the excess flow check valve will not reopen until the pressure differential on both sides of the valve is equalized. Remember that the railcar pressure monitor is downstream of the vapor check valve and therefore will not read car pressure if the excess flow check valve is closed.

Inerting the Unloaded Railcar for Return

Unloading a tank or a shipping container of liquid EO does not remove the danger of vapor decomposition because unloaded railcars contain a residual heel of EO liquid. The heel results in the continued presence of EO vapor. As long as EO vapor remains in a vessel, the railcar needs to be pressurized to maintain an inert atmosphere using either pure nitrogen, or in the alternative, vapors displaced from the EO storage tank into which the railcar is discharged. Railcar pressurization is a DOT requirement found at 49 CFR, Chapter 1, Part 173.323 (f).

After the cargo of EO is unloaded, the transfer lines to EO storage are blown with nitrogen. Once nitrogen flow is evident in the receiving tank or vessel, the liquid unloading line is closed and secured.

The composition of the vapor space within a railcar can be significantly affected by temperature and vaporization of the remaining heel. As a consequence, railcar inerting requirements differ significantly from those defined for storage tanks and are dependent on the source of the inerting gas.

EO railcars are designed to leave minimal volumes of residual liquid (typically less than 50 gallons) after the cargo is discharged. Tables 9.1 and 9.2 illustrate railcar pressurization for a 50 gallon heel.

The data in Tables 9.1 and 9.2 are valid for a 50 gallon heel. Higher minimum pressures are used for larger heels to achieve proper inerting and lower maximum pressures are used to prevent lifting of the relief valve.

In Tables 9.1 and 9,2, it is assumed that the inert atmosphere will be maintained up to a temperature of 105°F (as required by DOT) while maintaining the railcar pressure below the 75 psig setpoint of the pressure safety valve. This illustration addresses pressurization with either pure nitrogen or tank vapors from an EO storage tank inerted with nitrogen.

This illustration addresses potential vaporization of EO into the vapor space that might occur during the time interval required for unloading, pressuring, and securing the railcar. (See Appendix C for additional information.)

Table 9.1 Illustration – Pressuring Unloaded Railcars with Pure Nitrogen (Assuming 50 Gallon Ethylene Oxide Liquid Heel)

Pure Nitrogen Makeup			
50 GALLON EO LIQUID HEEL			
Railcar Temperature Range –°F		Railcar Pressure – PSIG	
From	To	Minimum[1]	Maximum[2]
25	30	20	50
31	35	20	50
36	40	20	51
41	45	20	52
46	50	20	53
51	55	20	53
56	60	20	54
61	65	20	55
66	70	20	55
71	75	20	56
76	80	20	57
81	85	20	58

[1] *Minimum is set to meet DOT requirement for a non flammable vapor space at 105°F.*

[2] *Maximum is designed to reduce likelihood of potential release from relief valve in transit should the railcar reach or exceed a temperature of 105°F.*

Pressuring unloaded EO railcars by vapor balancing (EO receiving tank vapors) for return to the supplier is slightly more complex, because the level of pressurization is dependent on the starting temperature of the EO tank from which the vapors are directed to the railcar. Supplementary pure nitrogen may need to be added to the railcar if the balance tank vapors cannot provide the necessary pressure level required to achieve an inert vapor space as dictated by DOT regulations.

Table 9.2 Illustration – Repressuring Unloaded Railcars – Vapor Balancing (50 Gallon Ethylene Oxide Liquid Heel)

VAPOR BALANCING			
LESS THAN 50 GALLON EO LIQUID HEEL			
Balance Tank Temp. Range –°F		Railcar Pressure – PSIG	
From	To	Minimum[1]	Maximum[2]
25	30	20	50
31	35	20	50
36	40	20	50
41	45	20	50
46	50	21	52
51	55	24	53
56	60	28	53
61	65	31	53
66	70	35	53
71	75	39	53
76	80	43	53
81	85	46	55

[1] *Minimum is set to meet DOT requirement for a non flammable vapor space at 105°F.*

[2] *Maximum is designed to reduce likelihood of potential release from relief valve in transit should the railcar reach or exceed a temperature of 105°F.*

9.5 IM Portable Tanks (Intermodal/Iso-Containers)

Although movement of EO in IM Portable Tanks (Intermodal/Iso Containers) is practiced in various regions of the world and also is approved as a mode of transportation in North America, IM Portable Tanks are not typically utilized for EO service in North America.

More information concerning rules and regulations for IM Portable Tanks in EO service are found in the Code of Federal Regulations Title 49—Transportation. EO is considered a hazardous, liqueified compressed gas by the U.S. DOT. The following sections of CFR Title 49 specifically address the use of IM Portable tanks for EO and other hazardous, liquified compressed gases (other regulatory sections may also apply):

- 172.101-102;
- 173.32;
- 173.323;
- 178.245 -1 through 7; and
- 178.272-276

9.6 Non-Bulk Packaging for High Purity Ethylene Oxide

EO can be shipped in small quantities in cylinders and drums. It is a violation of federal law to use a cylinder or drum of EO in a manner inconsistent with its labeling. Only qualified EO handling facilities, with appropriate safeguards and properly trained personnel, following applicable local, state, and federal laws, should fill non-bulk EO containers.

The most common use of EO in non-bulk packaging is for the sterilization of medical devices and reduction of microbial load in spices. These activities must comply with EPA's regulation of pesticides under the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) at 40 CFR Subchapter E and FDA's Quality Systems Regulation (21 CFR 820).

The following discussion addresses EO in DOT specification cylinders and UN 1A1 Drums. Transportation-specific comments apply to shipments that fall under the DOT hazardous materials table (49 CFR 172.101) description "Ethylene Oxide with Nitrogen." This section applies only when EO is the primary component in the container, apart from the nitrogen inerting gas, and that the contained EO is in the liquid phase. Specific regulations cited here may not apply to users of EO in other non-bulk packaging.

Design – General

EO in non-bulk packaging must meet the requirements of 49 CFR 173.323 (b). Cylinders must meet DOT Specification Cylinder Requirements of 49 CFR 173.40 and UN 1A1 Drums must comply with 49 CFR 178.504. Commonly used non-bulk containers are:

- 400 Pound 1A1 Drum
- 175 Pound 4BW240 Cylinder
- 20 Pound 4BW240 Cylinder

Figure 9.6 Commonly Used Non-bulk Containers

All non-bulk packaging of EO must be labeled in accordance with federal regulatory requirements. DOT hazard labels for both the primary (2.3) and subsidiary (2.1) hazards must be properly affixed to the containers and any outer packaging. OSHA Hazard Communication requirements (29 CFR 1910.1200) and applicable EPA FIFRA (40 CFR 156) labeling requirements must be met. Note that OSHA also has an ethylene oxide-specific standard that should be consulted (29 CFR 1910.1047).

Non-bulk containers must be equipped with insulation of sufficient thermal resistance and provided with adequate pressure relief devices to prevent rupture when exposed to fire. Cylinders and drums are equipped with fusible relief devices with yield temperatures of 157°F to 170°F (69°C to 77°C). Cylinders and drums have a pressure relief device that relieves at 75 psig. Refer to 49 CFR 173.323 and CGA Pamphlets S-1.1 and C-14.

EO in containers or cylinders is padded with dry nitrogen at sufficient pressure to render the vapor space non-flammable (e.g., up to 41°C (105°F)). Nitrogen is typically padded to a pressure of 50 psig.

EO may be shipped in UN 1A1 insulated steel drums of no more than 61 gallons (231 liters) capacity. Packing Group I performance standards are set out at Title 49 of the Code of Federal Regulations, Part 178.600 et seq.

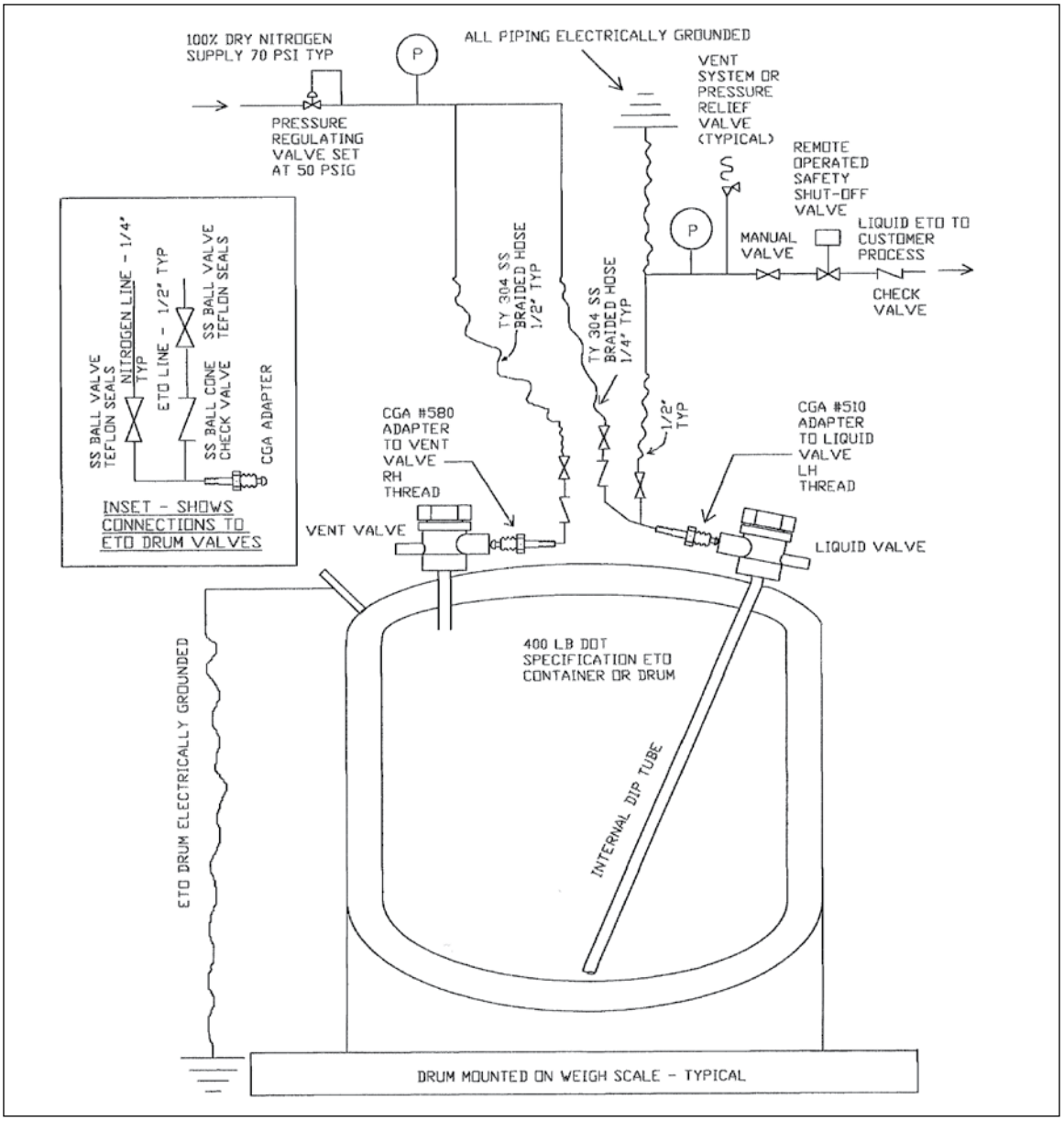
Federal regulations require UN 1A1 drums to be of all welded construction with a non-removable head. “The inner, pressure-containing shell must have a minimum thickness of 0.068 inches (1.7-mm), and the outer shell a minimum thickness of 0.095 inches (2.4 mm). Drums must be capable of withstanding a hydrostatic test pressure of 100 psig (690 kPa). Openings for filling, unloading and venting in the bodies or heads of non-removable head (1A1) drums may not exceed 3 inches (7.0 cm) in diameter. Closures for openings in the bodies and heads of drums must be designed and applied so that they will remain secure and leakproof under normal conditions of transport.

Regulations also require cylinders over 1 gallon (4 liters) capacity to have pressurizing valves and insulation. Eductor tubes must be provided for cylinders over 5 gallons (19 liters) capacity. Cylinders must be seamless or welded steel (not brazed) with a nominal¡ capacity of no more than 30 gallons (115 liters). Each cylinder must be equipped with a fusible-type relief device with yield temperature of 157°F to 170°F (69°C to 77°C). The capacity of the relief device and the effectiveness of the insulation must be sufficient to prevent a charged cylinder from exploding when tested by the method described in CGA Pamphlet C-14 or other equivalent method.

There are two valves commonly used in drum and cylinder service: a nitrogen valve and a liquid valve with an attached dip tube. A nitrogen valve (CGA 580) is used to pressurize the container with nitrogen. This valve has a spring activated relief which is set at 75psig by CGA requirements, and can only operate when the valve is open. This valve provides relief to protect the package from over-pressurization while in use only. If the relief is activated, it will reset once pressure is reduced below 75 psig. This valve has a CGA 580 right-hand internal thread connection with a silver handle.

A liquid valve (CGA 510) is used to unload the contents of the container. There is a dip tube threaded into the valve that extends to the bottom of the container which is used for liquid unloading. This valve has a CGA 510 left-handed internal thread connection with a red handle.

Figure 9.7 Typical Drum Connections



Preparation for Unloading Containers from Transport Vehicles

Federal regulations require all persons offering EO for transportation to be trained with respect to general awareness and familiarization; function-specific requirements; safety - emergency response; and hazardous material security. 49 CFR 172.704. Refresher training must be conducted at intervals not exceeding 3 years. See also Chapter 11, Selected Regulations.

Users of drums and cylinders may also wish to consult CGA Pamphlets P-1 (Safe Handling of Compressed Gases in Containers) and PS-7 (Position Statement on the Safe Transportation of Cylinders in Vehicles).

There are several National Fire Protection Association (NFPA) standards that may be applicable to a particular use: NFPA 55 (Compressed & Liquefied Gases in Cylinders) and NFPA 560 (Standard for Handling, Storage, Use of EO for Sterilization/Fumigation). Other standards may be applicable.

Advance arrangements for transportation of drums and cylinders are generally made by the supplier of the EO. If the end user chooses to return emptied containers, transporters/carriers should have any

necessary regulatory approvals for transporting or handling hazardous materials, and should be sufficiently familiar with the properties and hazards of EO to transport the materials safely. The DOT requires all carriers and end users of EO to be registered as handlers of hazardous material and to comply with the DOT security rule. Note that suppliers often request or require that they be contacted before unloaded EO non-bulk containers are returned to them.

Unloading Drums and Cylinders from Transport Vehicles

After the vehicle carrying drums or cylinders arrives at its delivery destination, the engine is generally shut off (unless needed to remain on for a particular purpose, such as to operate a lift gate) to minimize risk of ignition. Chocking the wheels and using the handbrake of the truck or other motorized vehicle will help prevent the truck from moving and keep it stable during the unloading process.

All areas for unloading or storage of EO are considered Class 1, Division 2, and Group B as defined by the National Electrical Code. The NEC prohibits open flames, smoking, or other combustion sources in the vicinity of the vehicle being unloaded. Give consideration to providing adequate ventilation in the unloading area during the unloading process, and in trucks or other motorized vehicles before and during the unloading process.

Use caution when entering a trailer or other transport vehicle that may contain the drums or cylinders of EO; in this regard, the use of area or portable EO-specific detection devices can be a very useful tool. During the unloading process, check the containers for damage and leaks. If a leak is suspected or any containers are damaged, initiate appropriate emergency response procedures and contact the supplier.

Unloading drums and cylinders must be performed with care. Puncturing or damaging the drums is to be avoided, as is exposing them to heat or fumes. Select unloading equipment that will avoid or minimize damage to drums and cylinders. Using a handtruck or pallet jack, as appropriate, will help avoid rough handling of the drums (rolling, dragging, or sliding them), which can damage them, and also helps avoid the risk of damage from the use of powered equipment (such as motorized forklifts). Also note that some cylinders and drums are equipped with caps to help protect valves from damage; having these caps in place during all times except when needed to access the valve helps protect the cylinders and drums.

Full and unloaded drums are also stored with care. They are generally designed to be stored upright, in a well-ventilated area. Damage to an eductor tube can occur to a cylinder stored on its side. It is desirable to store the drums in a manner that avoids heat build up, so consider controlling the temperature of the storage area and sheltering the drums to avoid direct sunlight or other sources of heat. Give consideration to the location of the pressure relief devices (ability to vent without obstruction or other safety considerations) while the drums are stored. Store drums in a manner to provide adequate protection from physical damage, and provide an adequate schedule of checking for cracks, leaks, faulty valves, or other circumstances to be addressed.

Unloading (Discharging) Drum and Cylinder Contents

The information provided in this section is intended to introduce information and general principles of safe handling with regard to the receipt, use and return of cylinders and drums containing EO. The end user should request detailed instructions from the EO supplier concerning specific types of cylinders or drums.

Considerations while unloading drums and cylinders include:

- Cylinder or drum fittings are inspected for wear or possible damage. (Where damaged cylinders/drums are identified, contact the supplier for further instructions).
- The threaded connections and valve are inspected for dirt, grease, or obstructions. Note that some threaded connections may be designed to work without lubricants, and the use of lubricants on such threadings may impede performance.
- Use of a check valve or other backflow prevention device in the discharge line will help prevent backflow and entry of contaminants into the EO cylinder or drum.
- Use of spark-resistant tools can help minimize the risk of sparking.

At all times during unloading, the container is properly secured. This helps avoid unintentional movement or fall of the container. When selecting a storage area, consider locations that will minimize inadvertent contact that could lead to a puncture; for example, storage areas well away from traffic lanes. Note that drums and cylinders may be designed for valve protection, such as cylinder caps valve plugs, to be kept in place and secured at all times when the container is not being loaded or unloaded.

Nitrogen is used to maintain cylinder and drum pressure and to discharge the EO from the container. (The valve located at the discharge connection of the drum or cylinder is useful for throttling and regulating the flow of EO from the container and also for providing the required backpressure to maintain the container vapor space within the non-flammable inert region.) The nitrogen is at a high enough pressure to maintain the container vapor space within the non-flammable or inert region. Follow the supplier's instructions regarding appropriate pressure to achieve inerting. With the drum and cylinder designs discussed in this manual, a pressure of about 50 psig has been used in practice for pressuring and unloading a cylinder or drum. Note that the use of a backpressure control valve or regulator can help prevent overpressuring the EO drum or cylinder.

Securing the Unloaded Drum or Cylinder for Return to Supplier

An emptied drum or cylinder may contain residual quantities of EO, which can pose a danger of vapor decomposition. Due to possible residual EO, these containers are handled very carefully.

DOT regulations require that any unloaded cylinder or drum containing the residue of a hazardous material be transported in the same manner as when it previously contained a greater quantity of that hazardous material. DOT requires containers to be returned to the supplier as a hazardous material. Packages must retain DOT Hazard markings 2.3 and 2.1 (Poison Gas placard and Flammable Gas placard). DOT regulations require the shipper to ensure that any truck carrying EO is appropriately placarded.

9.7 Ethylene Oxide Shipping Data

Table 9.3 Temperature/Density/Vapor Pressure for Shipping Ethylene Oxide

Temperature	Density (lb/gal)	Vapor Pressure (psia)
20°F	7.59	7.1
40°F	7.47	11.6
60°F	7.34	18.0
80°F	7.21	26.9
100°F	7.08	39.1
105°F	7.05	42.7

According to DOT federal regulations (49 CFR 173.24b), EO railcars and portable tanks must be loaded to ensure that a 5% outage exists at a temperature of 105° F.

9.8 Shipments of Ethylene Oxide between the U.S. and Canada

Canada has established regulations for the Transportation of Dangerous Goods (TDG) within Canada. Canada identifies EO as a dangerous good subject to TDG rules. This section provides a brief overview of Canadian requirements; the user should consult the regulations for more information.

Canadian TDG regulations require that the importer of record for EO into Canada must have an approved emergency response assistance plan (ERAP) on file with Transport Canada. Part 7 of the TDG Regulations outlines this requirement and Column 7 of the dangerous goods list provides the ERAP Index.

Shipments of EO from within the U.S. to, or through Canada

TDG Regulations allow shipments of EO that originate from within the United States to be transported into or through Canada under the classification, marking, labeling, placarding and documentation requirements of Title 49 of the US Code of Federal Regulations (49 CFR).

More details concerning *Transportation of Dangerous Goods from the United States into or through Canada* can be found in the Canadian Government's Transport of Dangerous Goods Regulations, Sections 9.1 and 10.1, and other referenced sections, for the shipment of EO by either road or rail, respectively.

Shipments of EO from within Canada to, or through the U.S.

The U.S. DOT has established provisions for EO shipments originating within Canada that terminate within the United States, or which travel through the United States to a Canadian or foreign destination. These regulations also apply to the return to Canada of any unloaded bulk packages containing residues of hazardous materials that were originally imported into the United States.

Shipments of EO originating within Canada that are properly marked, labeled, placarded, described on a shipping paper, and packaged in accordance with the Transportation of Dangerous Goods (TDG) Regulations issued by the Government of Canada may be transported to or through the United States by railcar or tankwagon / road vehicle, provided that:

- Shipping papers contain the words "Toxic Inhalation Hazard" or "Poison Inhalation Hazard" or "Inhalation Hazard"; and
- A label or placard that conforms to the specifications in the TDG Regulations for a "Class 2.3" label or placard may be substituted for the POISON GAS or POISON INHALATION HAZARD label or placard, and
- The containers used for shipping EO as authorized by the TDG Regulations correspond to the USDOT specification or UN packaging specifications for EO.

Details concerning the shipment of hazardous materials originating from within Canada can be found in the U.S. Code of Federal Regulations, Title 49, Part 171.12a, Canadian Shipments and Packaging.