HANDLING AND TRANSPORTATION GUIDE FOR ETHYLENE, REFRIGERATED LIQUID (CRYOGENIC ETHYLENE)

April 2004

Cryogenic Ethylene Transportation Safety Panel
American Chemistry Council
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Members of Cryogenic Ethylene Transportation Safety Panel

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Burlington Northern Santa Fe Railway Company

Chart Industries

Eagle Construction & Environmental

Eastman Chemical Company

Equistar Chemicals, LP

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Jack B. Kelley, Inc.

Phillips Petroleum Company

Praxair, Inc./AMKO Service Company

Quality Distribution, Inc.

Sunoco, Inc.

Texana Tank Car & Manufacturing Ltd.

Union Pacific Railroad

1.0 INTRODUCTION

1.1 Introduction

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 CHEMSTAR Cryogenic Ethylene Transportation Safety Panel (Panel) created this Guide for handling and transportation of "Ethylene, Refrigerated Liquid," referred to here as "cryogenic ethylene." The purpose of this Guide is to provide the reader with a better understanding of the characteristics of cryogenic ethylene. The Guide also addresses the health, safety, and environmental aspects associated with the distribution and use of cryogenic ethylene. The reader should note that a separate manual addressing ethylene (non-cryogenic) has been prepared by the American Chemistry Council's Olefins Panel, Ethylene Product Stewardship Task Group.

This Guide has been prepared for use by producers, industrial users, and transporters of cryogenic ethylene, including loading and unloading personnel, trainers, and emergency responders.

The Panel is made up of representatives of the following American Chemistry Council member and affiliated companies:

Air Products and Chemicals, Inc. * ╪
Burlington Northern Santa Fe Railway Company *
Chart Industries *
Eagle Construction & Environmental *
Eastman Chemical Company ╪
Equistar Chemicals, LP
Huntsman Corporation
Jack B. Kelley, Inc. * ╪
Phillips Petroleum Company *
Praxair, Inc./AMKO Service Company * ╪
Quality Distribution, Inc. *
Sunoco, Inc. ╪
Texana Tank Car & Manufacturing Ltd. *
Union Pacific Railroad *

╪ Member of the American Chemistry Council

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* Supporters of the Cryogenic Ethylene Transportation Safety Panel that **do not** manufacture cryogenic ethylene.

We encourage feedback on the value of the information provided in the Guide and hope that this document will be a useful resource for you. This document may be updated. Contact your supplier if you have questions, or for more information on any item contained in this Guide.

Special Note:
In this Guide, rail cars will be referred to as "tank cars," tank trucks will be referred to as "cargo tanks," and ISO containers will be referred to as "Isotainers."

1.2 Legal Notice

The Handling and Transportation Guide for Ethylene, Refrigerated Liquid (Cryogenic Ethylene) was prepared by the American Chemistry Council's Cryogenic Ethylene Transportation Safety Panel. It is intended to provide general information to persons who may handle or transport cryogenic ethylene. It is not intended to serve as a substitute for in-depth training or specific handling or storage requirements, nor is it designed or intended to define or create legal rights or obligations. It is not intended to be a "how-to" manual, nor is it a prescriptive guide. All persons involved in handling, transporting, and storing ethylene have an independent obligation to ascertain that their actions are in compliance with current federal, state and local laws and regulations and should consult with legal counsel concerning such matters. This Guide is necessarily general in nature and individual companies may vary their approach with respect to particular practices based on specific factual circumstance, the practicality and effectiveness of particular actions, and economic and technological feasibility.

Neither the American Chemistry Council, nor the individual member companies of the Cryogenic Ethylene Transportation Safety Panel, nor any of their employees, subcontractors, consultants, or other assigns, makes any warranty or representation, either express or implied, with respect to the accuracy or completeness of the information contained in this Guide; nor do the American Chemistry Council or any member companies assume any liability or responsibility for any use, or the results of such use, of any information, procedure, conclusion, opinion, product, or process disclosed in this Guide.

For more information on material presented in this Guide, please contact your supplier.

1.3 Updates

This Guide has been designated and distributed in a manner that accommodates periodic updates. Because this Guide may be updated periodically, refer to the most recent version of the Guide which is posted on the American Chemistry Council's Website (*www.americanchemistry.com*) under "Affiliate Links." All prior versions of the Guide are considered out of date. The American Chemistry Council and members of the Cryogenic Ethylene Transportation Safety Panel assume no responsibility to amend, revise, retract, or update this Guide to reflect information that may be available after posting on the website. Removal of this Guide from the website means that it is no longer in publication, may be outdated, and should not be used.

2.0 PHYSICAL PROPERTIES AND HAZARDS

The information in this section is largely based on the Association of American Railroads' Emergency Action Guide and the U.S. Department of Transportation's Emergency Response Guidebook.

2.1 General Information and Hazard Ratings

Ethylene is a colorless gas having a faint, slightly sweet odor. It is practically insoluble in water. Cold ethylene gas is heavier than air and may travel a considerable distance to a source of ignition. Cryogenic ethylene weighs approximately 4.7 pounds per gallon at its boiling point at atmospheric pressure.

Ethylene is not significantly toxic by inhalation, but high concentrations may be anesthetic or may cause asphyxiation via displacement of air. Contact with cryogenic ethylene and concentrated cold ethylene gas may cause frostbite.

Ethylene is transported as a compressed gas or cryogenic liquid and used for a variety of applications, including refrigeration and for making plastics and organic chemicals.

Containers of cryogenic ethylene may rupture violently if exposed to fire or excessive heat for sufficient time duration. Products of combustion may include carbon monoxide.

If a tank car, cargo tank or "Isotainer" is exposed to direct flame or fire becomes uncontrollable, the Association of American Railroads Emergency Action Guide recommends evacuation to a radius of one half (1/2) mile. In the United States, CHEMTREC® (800-424-9300) can be called for assistance in any transportation emergency or if a potentially dangerous or problem situation might occur. Emergency response is addressed in section 7.0 of this Guide.

Hazard Ratings	Health	Fire	Reactivity
NFPA	**1**	**4**	**2**
HMIS	**1**	**4**	**2**
Key: 0 = Least, 1 = Slight, 2 = Moderate, 3 = High, 4 = Extreme			

2.2 Chemical and Physical Properties of Ethylene

Property	Value
CAS Number	74-85-1
Physical State	Gas, Liquid Under Pressure
Color	Colorless
Odor	Faint, sweet
Molecular Formula	C_2H_4
Molecular Weight	28.0538
Normal Boiling Point (at 1 atmosphere)	-154.7°F (-103.7°C)
Melting Point	-272°F (-113°C)
Critical Temperature	48.54°F (9.19 °C)
Critical Pressure	731.14 psia
Critical Volume	0.07480 ft3/lb
Critical Compressibility Factor	0.281
Expansion Coefficient	472.5:1 at 60oF (15.6 oC)
Density (liquid), @Critical Temperature, 48.54°F (9.18°C)	13.36 lb/ft3 (1.786 lb/gal)
Relative Vapor Density @ 32°F (0 °C) (gas; air = 1)2	0.975
Vapor Pressure, @ 70°F (21°C)	938.5 psia
Liquid Heat Capacity @Critical Temperature, 48.54°F (9.18°C)	1.236 BTU/lb °F
Ideal Gas Heat Capacity, @70°F (21°C)	0.3626 BTU/lb*°F
Corrosiveness	Non-corrosive
Solubility in Water, @68°F (20 °C)	131 mg/l
Solubility with other chemicals	Acetone, alcohol, benzene and ether
Viscosity (liquid), @Critical Temperature, 48.54°F (9.18°C)	3.06E-05 lb/ft * s
Viscosity (vapor), @70°F (21°C)	6.77E-06 lb/ft * s
Ideal Gas Heat of Formation @77°F (25°C)	805.25 BTU/lb
Heat of Vaporization, @Critical Temperature, 48.54°F (9.18°C)	3.07 BTU/lb
Autoignition Temperature	842°F (450°C) to 914°F (490°C)
Explosive Limits in Air, Vol. % @77°F, 1 atm	
Lower	2.3 – 3.02
Upper	28.6 - 36
Odor Threshold in Air	
Detection4	270 - 600 ppm
Recognition4	418 ppm

[1] Daubert, T.E., Danner, R.P., Sibul, H.M., and Stebbins, C.C., DIPPR® Data Compilation of Pure Compound Properties, Project 801 Sponsor Release, January,1994, Design Institute for Physical Property Data, AIChE, New York, N.Y. Note: Semiannual updates released in January and July, except as noted otherwise.

[2] Hawley, G.G., "The Condensed Chemical Dictionary", 8th ed., .New York, NY, Van Nostrand Reinhold Co., 1971, p. 362.

[3] Hansch, C., Leo, A., "Substituent Constants for Correlation Analysis in Chemistry and Biology," New York, N.Y., John Wiley and Sons, 1979, p.175.

2.3 Health Hazard Information

This section provides a brief overview of information pertaining to potential health and environmental hazards associated with exposure of cryogenic ethylene. A comprehensive discussion of health and environmental effects pertaining to cryogenic ethylene is beyond the scope of the Guide. For more information, you may want to contact your supplier. Additional information, including first aid information, may also be found in your supplier's Material Safety Data Sheet (MSDS).

2.3.1 Acute Inhalation Exposure

Ethylene gas is a simple asphxiant that may cause death by displacement of air at very high concentrations. Moderate concentrations may cause headache, drowsiness, muscular weakness, dizziness and unconsciousness.

2.3.2 Exposure Limits

Exposure Limit	Organization	Value
Short Term Exposure Limit (STEL)	ACGIH	Not Established
Threshold Limit Value (TLV)	ACGIH	100 ppm (proposed)
Permissible Exposure Limit (PEL)	OSHA	Not Established
Immediately Dangerous to Life and Health (IDLH)	NIOSH	Not Established
Emergency Response Planning Guideline (ERPG)	AIHA	Not Established
International (8 hr – TWA)	Sweden	250 ppm
International (Short Term Exposures)	Sweden	ppm

2.3.3 Carcinogenicity

Ethylene is not listed as a carcinogen by the International Agency for Research on Cancer (IARC) and the National Toxicology Program (NTP).

2.3.4 Skin or Eye Contact

Contact of the skin or eyes with venting gas or cryogenic ethylene may result in frostbite.

2.3.5 Ingestion

Contact with liquid or gas may cause frostbite.

3.0 PERSONAL PROTECTIVE EQUIPMENT AND SPILL RESPONSE

This section provides general information on appropriate personal protective equipment and spill response. In addition to the regulations and guidance referenced below, the U.S. Department of Transportation's Emergency Response Guidebook, Guide 115, "Gases – Flammable (Including Refrigerated Liquid)" is a valuable reference tool.

3.1 Personal Protective Equipment

3.1.1 Respiratory Protection

Ethylene is listed as a simple asphyxiant by the Occupational Safety and Health Association (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH). Ethylene as a gas or vapor displaces oxygen when present in high concentrations in air. An oxygen deficient atmosphere can cause drowsiness, dizziness, unconsciousness, and/or suffocation by asphyxiation. Respiratory protection should be used in accordance with company and applicable OSHA regulatory requirements. OSHA regulations require that persons not be assigned to tasks requiring the use of respirators unless it has been determined they are physically able to perform the work and are trained to use the equipment (29 CFR §1910.134).

Cryogenic ethylene should be handled with adequate ventilation to keep exposure below the exposure limits discussed in Table 2.3.2. In many cases, local ventilation may not be necessary to keep exposure below the exposure limit. However, if local ventilation is used, the user should be aware of American National Standards Institute (ANSI), OSHA, and American Society of Heating, Refrigeration, and Air Conditioning (ASHRAE) national standards for explosion-proof ventilation equipment. For unknown concentrations, OSHA regulations require the highest level of respiratory protection, i.e., self-contained breathing apparatus (SCBA) with full face piece and positive pressure.

3.1.2 Chemical Protective Clothing

Frostbite may result from the cooling effect of rapidly evaporating cryogenic ethylene. The level of protection selected considers factors including the potential ethylene concentration and likelihood of contact. It could range from no chemical protective clothing (CPC) (as could potentially be the case where when ethylene is handled in closed systems and there is no personnel exposure) to higher levels of protection such as firefighter turn-out gear or fire proximity suit with supplied-air respirators (for situations such as high concentration large spills or leaks).

No single protective clothing material will protect against all dangerous goods. Do not assume any protective clothing is resistant to cold and/or heat or flame exposure unless it is certified by the manufacturer (NFPA 1991 5-3 Flammability Resistance Test and 5-6 Cold Temperature Performance Test). When selecting specific products the material manufacturer should be contacted. Thermal insulating properties for frostbite and permeation may be a consideration in CPC material selection.

Special note on insulated gloves:
At time of publication, there are no insulated gloves designed to allow hands to be put into a cryogenic liquid. Insulated gloves provide only short-term protection from accidental contact with the liquid.

3.1.3 Eye and Face Protection

The eyes are highly sensitive to the extreme cold of the liquid and vapors of cryogenic materials. Typically, the recommended personal protective equipment for handling cryogens includes a full-face shield over chemical goggles. Appropriate eye and face protection may be necessary to prevent contact with ethylene. A hazard assessment conducted in accordance with the requirements of the OSHA standard for Personal Protective Equipment (29 CFR §1910.132) can help to determine the level of protection necessary. Further information may be obtained from OSHA's general requirements section of its Eye and Face Protection Standard (29 CFR §1910.133).

Protective eye/face devices purchased after July 5, 1994 must comply with ANSI Z87.1-1989. If purchased on or before July 5, 1994, protective devices should at least comply with ANSI Z87.1-1968.

3.2 Exposure Monitoring

A number of methods are available for monitoring employee exposures to ethylene. The following information addresses some of these methods. Please note that this section is not intended to be a complete review and evaluation of ethylene sampling and analytical methods. The employer is responsible for determining the accuracy and precision of a monitoring method relevant to the unique conditions of the specific workplace, no matter what method is chosen. For more information, contact your ethylene supplier.

3.2.1 Detector Tubes

A number of detector tubes for use with volumetric pumps to measure ethylene concentrations are commercially available. These colorimetric-indicating tubes provide a direct reading of the ethylene concentration. A specified amount of air is drawn through the tube, and the ethylene present in the air reacts with the solid sorbent to produce a color change whose length-of-stain is directly proportional to the ethylene concentration.

Interferences and sampling time are other issues to be considered with the use of colorimetric detector tubes. Chemical substances that may interfere with these tubes include other compounds with C=C double bonds (butylene, propylene, etc.), H_2S (hydrogen sulfide), and CO (carbon monoxide). The presence of these chemicals may cause false positive results. Current colorimetric tubes can require 4 to 30 minutes of sample acquisition time to determine a reading.

3.2.2 Direct Reading, Portable Instruments

Photoionization detectors (PID) can be used to measure for ethylene in low- to sub-ppm concentrations. A significant possible limitation of PIDs, however, is that these instruments will respond to a wide range of hydrocarbons in addition to ethylene. Use of a specific response factor with the correct lamp will help maximize the approximate value of reading for ethylene.

3.3 Fire and Explosion

Ethylene presents a significant fire and explosion hazard based on its physical properties, including flashpoint, vapor pressure, and boiling point. It can quite readily form explosive mixtures in air as a result of its high vapor pressure. Therefore, preventive measures must be taken to minimize the potential for a fire or explosion.

Ethylene is extremely flammable and is classified as a flammable gas by OSHA and the Department of Transportation (DOT). Ethylene concentrations in air between 2.3% and 32.3% can form explosive mixtures. If an ignition source is present, a fire and/or explosion can result. At temperatures of approximately 842^{o} F or above, this material can autoignite. In other words, it can spontaneously ignite without the application of flame or spark if it is heated above this temperature.

Vapors of ethylene are slightly lighter than air (0.975 w/air =1). A vapor with a vapor density less than 1 is lighter than air and would tend to rise in air. The stratification based on vapor density is most significant while the vapor or gas is being introduced to a space. Given sufficient time, gases will diffuse throughout the space. An ethylene gas release may produce a visible fog when it is escaping in a non-fire emergency situation such as a spill or leak. The fog is the result of the liquid vaporization, which condenses water vapor from air. It should be noted that the fog is only an approximate indicator of the amount of ethylene in the area.

The invisible, ignitable ethylene/air mixture can extend up to a half mile beyond the visible fog from the source of a large leak. In a fire situation, conditions can develop which could lead to explosions and further fire propagation. The build-up of pressure in closed containers of ethylene caused by elevated temperatures can result in container failure. Containers may be subject to a “boiling liquid expanding vapor explosion,” or BLEVE. Because ethylene will polymerize only at elevated temperature and pressure in the presence of a catalyst, polymerization in a transportation incident is highly unlikely.

Responding to a fire requires analysis of all site conditions for decision-making purposes; however, some basic general principles can be applied to help formulate the response decisions. Stopping the flow of ethylene gas or liquid helps extinguish an ethylene fire by cutting off the source of fuel. Carbon dioxide, certain dry chemical fire suppressants, and/or water fog can be effective in suppressing an ethylene fire. High expansion foam may be effective on fires in liquid pools of ethylene.

In case of fire associated with ethylene, it is important to keep all authorized persons upwind a safe distance from the ethylene area. Firefighting personnel may need respiratory protection. (For additional information on respiratory protection, see Section 3.1.1.) Firefighting personnel should also be aware of the consequences of exposure to cryogenic ethylene, and appropriate clothing should be worn. (For additional information on personal protective equipment and clothing, see Sections 3.1.2 and 3.1.3.)

The removal of ethylene containers from the fire zone can also reduce some potential risks. Firefighters should be alert to the potential for fire-exposed containers to rupture as contained ethylene expands from heat. Keeping containers cool by supplying water streams to the exterior helps minimize the risk of rupture. (Note, however, that adding water to liquid pools of ethylene will act to raise the temperature of the pool, and may increase evolution of ethylene gas). The risk of container rupture means that firefighters applying water to the container should do so from an appropriate distance, and water should be supplied to the most structurally sound part of the container (which, on most undamaged containers, is usually the side).

A large fire in a cargo area can present a significant hazard to responders. Safety of firefighters and response personnel may be best guarded by use of unmanned hose holders or monitor nozzles. Note that a sound rising in pitch from a venting safety device, or tank discoloration, may signal imminent tank rupture, at which time personnel should quickly maintain an appropriate distance from the tank to protect against rupture.

3.4 Spill Response

As with fire response, responders to spills of cryogenic ethylene should consider site-specific circumstances when developing a response strategy, including the possibilities for fire and explosion discussed in Section 3.3. Eliminating ignition sources helps minimize the risk of fire and explosion. (Note that an internal combustion engine can be an ignition source, as intake of ethylene gas by an engine may result in its rupture or explosion).

Spill response personnel should also be aware of the possible consequences of exposure to cryogenic ethylene, which may result in damage to exposed skin or eyes. (For additional information, see Section 2.3 on possible health effects from exposure). Liquid pools of cryogenic ethylene may be extremely cold (approximately

–154° F). Accumulations of cold, heavy ethylene gas may persist in pits, hollows, and depressions. Application of water fog can be very effective in controlling ethylene vapors from these sources. (Note that application of a water stream to a pool of cryogenic ethylene is not effective because it will act to raise the temperature of the pool, creating more ethylene gas).

As with fire responders, spill responders may need personal protective equipment appropriate to cryogenic ethylene. (For additional information on respiratory protection, see Section 3.1.1). They may also need appropriate protective clothing. (For additional information on personal protective equipment and clothing, see Sections 3.1.2 and 3.1.3).

Restricting access to the spill area to response personnel is generally helpful. Unprotected personnel can be located upwind of the spill area to reduce the risk of exposure to ethylene gas. For sizable spills, evacuation may be an appropriate response step. Evacuation of the downwind area helps avoid subsequent injury from an ethylene fire or explosion. Evacuation distance should take into consideration the size of the fire (quantity of ethylene on fire), explosion risk, and other appropriate factors.

4.0 TRAINING

Persons who work with cryogenic ethylene or respond to emergencies involving cryogenic ethylene must be trained in its proper and safe handling and in accordance with applicable federal, state and local laws and regulations.

4.1 Hazardous Communication

All employees who work with hazardous chemicals, including cryogenic ethylene, must be trained in accordance with the Occupational Safety and Health Administration's (OSHA) Hazardous Materials Communication Standard (29 CFR §1910.1200). Employees should be provided with information and training on the hazards of cryogenic ethylene, methods for detecting releases, and methods of protection from exposure.

The materials safety data sheet (MSDS) is an important source of information. It contains information on health, safety, fire and protective measures.

4.2 Hazardous Material Emergency Response

All personnel responding to hazardous material incidents, including cryogenic ethylene, must be trained in accordance with OSHA's standard on Emergency Response (29 CFR §1910.120 [q]). Responders should be provided with information on the hazards of cryogenic ethylene, methods for detecting releases, methods of protection from exposure, isolation distances and options for mitigation.

4.3 HAZMAT Employees

Each HAZMAT employee must be provided with general awareness/familiarization, function-specific, and safety and security training in accordance with Department of Transportation (DOT) regulations. The specific DOT provisions applicable to the discussion of this section (4.3) may be found at 49 CFR §172.700 - 804.

4.3.1 General Awareness

General Awareness training is designed to provide familiarity with the requirements of the Department of Transportation's (DOT's) regulations for the transportation of hazardous materials and to enable the employee to recognize and identify hazardous materials consistent with DOT's hazardous communication standard.

4.3.2 Function Specific

Each HAZMAT Employee, including those who load, unload or transport cryogenic ethylene, must be provided with function-specific training for the positions and duties as they relate to DOT's regulations.

4.3.3 Safety Training

Federal regulations require HAZMAT employees to receive safety training that includes:

- Emergency response information;
- Measures to protect the employee from the hazards associated with the materials; and
- Methods and procedures for avoiding accidents, such as the proper procedures for handling packages containing hazardous materials.

4.3.4 Security Training

HAZMAT employees must receive training that provides an awareness of security risks associated with hazardous materials transportation and methods designed to enhance transportation security.

4.3.5 OSHA, EPA and Other Training

Training conducted by employers to comply with the hazard communication programs required by OSHA (29 CFR §1910.120 or §1910.1200), or training conducted by employers to comply with the requirements of other Federal or international agencies, maybe used to satisfy the training required by the DOT as long as such training addresses the components listed above.

5.0 TRANSPORTATION OF CRYOGENIC ETHYLENE

5.1 Tank Cars

Cryogenic ethylene is transported in specially built tank cars. These tank cars are insulated and vacuum-jacketed to keep cryogenic ethylene in a liquid state.

5.1.1 Regulations

DOT's general requirements for transporting cryogenic ethylene in tank cars are at 49 CFR §173.319. The construction requirements for tank cars are at 49 CFR §179.400.

5.1.2 Design and Construction

Cryogenic ethylene is transported in class DOT-113 tank cars. All class DOT-113 tank cars are constructed as a tank-within-a-tank. The space between the inner and outer tanks is insulated with either perlite or wrapped fiberglass or similar material, and is under vacuum. The insulation and vacuum reduce heat transfer from the outside, allowing the cryogenic ethylene to remain in a liquid state. Each tank car is protected by one or more pressure relief valves and one or more rupture (frangible) discs.

Tank Car

5.1.3 Operations

Each tank car transporting cryogenic ethylene must be in compliance with all applicable regulations, including markings and placards, the amount of material loaded, transit times, vacuum level, pressure relief valve retest, and rupture disc change out.

5.1.4 Hazard Communications

5.1.4.1 Marking

Each tank car transporting cryogenic ethylene must be legibly marked on both sides with "Ethylene, Refrigerated Liquid" (49 CFR §172.330(a)). The tank car

must also have the identification number "1038" on both sides and both ends (49 CFR §172.332). The identification number is usually incorporated into the placard.

Placard and Proper Shipping Name Marking

A tank car must also be marked "Do Not Hump or Cut Off While In Motion" and "Vacuum Jacketed" (49 CFR §179.400-25).

"Vacuum Jacketed" Stencil

"Do Not Hump" Stencil

Additionally, if a tank car is operating under the provisions of a DOT Exemption, it must be marked as required by the specific exemption.

5.1.4.2 Placarding

Each tank car must be placarded on both sides and both ends with the "flammable gas" placard (49 CFR §172.504). Additionally, the placard on a tank car must be placed on a square white background (49 CFR §172.510(a)). The identification number may be displayed on the placard (49 CFR §172.332(c)).

Cryogenic Ethylene Placard

5.1.4.3 Shipping Papers

Each shipment of cryogenic ethylene must have a shipping paper describing it as "ETHYLENE, REFRIGERATED LIQUID, 2.1, UN1038," and some indication of the total quantity, such as "1 Tank Car (T/C)," as appropriate (49 CFR §172.201).

For any shipment made under the provisions of a DOT Exemption, the shipping papers must state the exemption number, as "DOT-E" followed by the number of the exemption, unless specifically excepted in the exemption (49 CFR §107.101(g)(2)).

For both loaded and residue shipments in tank cars, the shipping papers must include the notation, "DOT-113, Do not hump or cut off car while in motion." Additionally, for residue shipments in tank cars, the shipping papers must include the notation, "RESIDUE: LAST CONTAINED," before the shipping name (49 CFR §173.203(e)(1-2)).

Example of shipping description:

```
1 T/C
ETHYLENE, REFRIGERATED LIQUID
2.1//UN1038
DOT-113, DO NOT HUMP OR CUT
  OFF CAR WHILE IN MOTION
```

5.1.4.4 Exemptions/Approvals

DOT grants exemptions for certain activities not otherwise authorized by regulation (49 CFR §107.101). Where exemptions are granted, there must be a demonstration that a level of safety for the exempt activity equivalent to that required by the regulation is maintained. DOT-E 12039 allows shipments in tank cars to be offered for transportation at a higher initial pressure, but requires a lower daily pressure rise (DOT-E 12039).

A copy of DOT Exemption 12039 may be found in Appendix 1.

DOT Exemption

5.1.4.5 Inspections

Prior to offering the tank car for transportation, the shipper must ensure that the tank car is in proper condition (49 CFR §173.22 and §173.31), including proper pressure and vacuum levels (49 CFR §173.319).

5.1.5 Tank Car Construction

5.1.5.1 General Information

Class DOT-113 tank cars are of special design so that cryogenic ethylene remains in a liquid state during transportation to the consignee. Class DOT-113 tank cars are vacuum-insulated cars, and have a stainless steel inner tank and a carbon steel outer tank (49 CFR §179.400-5). The following section relates only to those items that are unique to class DOT-113 tank cars.

5.1.5.2 Design and Construction

Class DOT-113 tank cars are designed for specific loading and shipping temperatures, and have certain materials and fittings requirements. Two types of class DOT-113 tank cars, which are designated by the intermediate letters below as "DOT-113C120W" or "DOT-113D120W," may be used for cryogenic ethylene service (49 CFR §173.319). The number "120" refers to the test pressure (120 psig) of the tank car.

C = Minus 260 degrees Fahrenheit (loading)
D = Minus 155 degrees Fahrenheit (loading) – not for new construction

Typical features of a class DOT-113 tank car are listed below (49 CFR §179.400):

Inner Tank

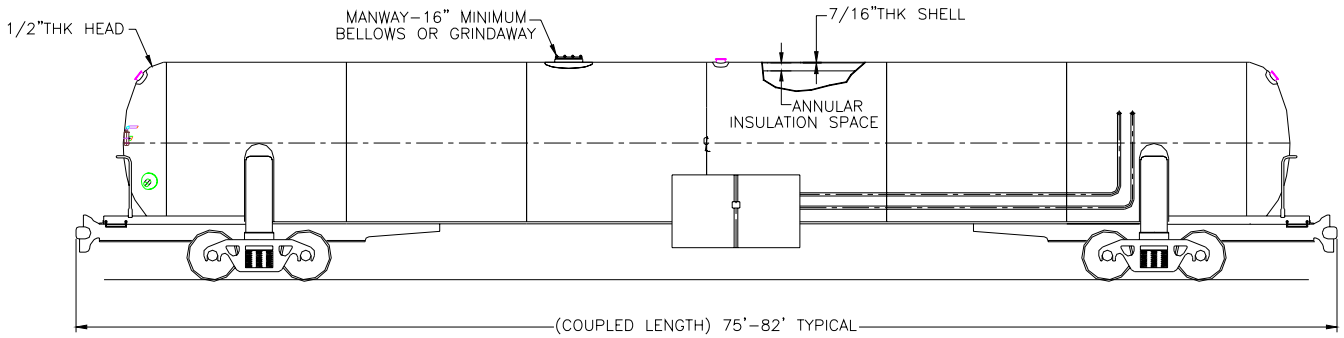
Thickness:	3/16” (minimum); 1/4” (nominal)
Material:	Stainless steel of ASTM A 240/A 240M, Type 304 or 304L

Outer Tank

Thickness:	1/2” heads, 7/16” shells
Material:	Carbon steel

Insulation

Perlite (common in 1960-1990 built cars), or
Wrapped fiberglass or similar material (common in 1990-and-later built cars)



Cutaway Drawing of Tank Car
(Courtesy of Chart Industries)

“D” Tank Cars:

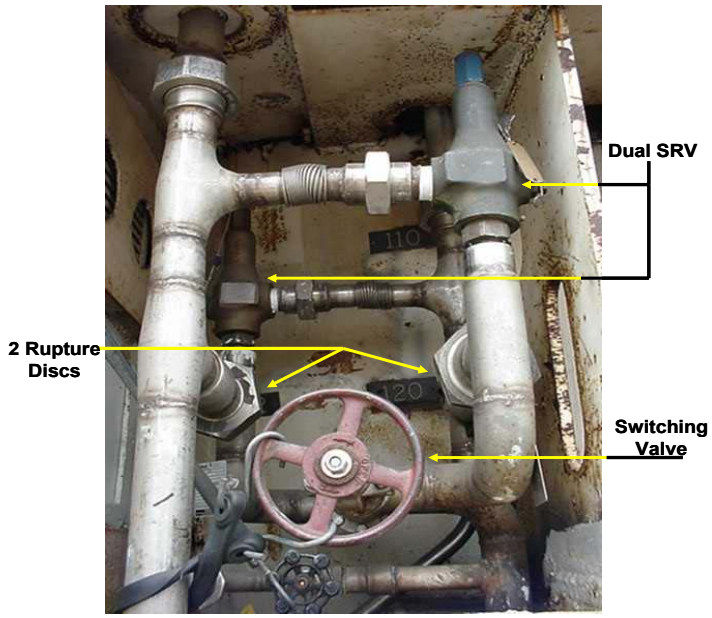
Class DOT-113D120W tank cars were built in the mid-1960’s and are the oldest of the tank cars used in cryogenic ethylene service. The class DOT-113D tank cars are typically known as “End Loaders,” and load from the “A” end of the tank car – which is opposite of the brake wheel, or “B” end – although exceptions may exist. Class DOT-113D tank cars may continue to be used in cryogenic ethylene service, but new construction is not authorized.

The rail weight limit for these tank cars is 263,000 pounds with a tare weight in the 131,000 to 133,000 pounds range. The water capacity of these tank cars is nominally 30,000 gallons, which allows for a payload of approximately 105,000 to 130,000 pounds (26,000 to 26,500 gallons) of cryogenic ethylene.

DOT-113 tank car with end-loading cabinet

Class DOT-113D tank cars are equipped with dual pressure relief valves and dual rupture discs.

113D120W Safety Valve and Rupture Disc Assembly

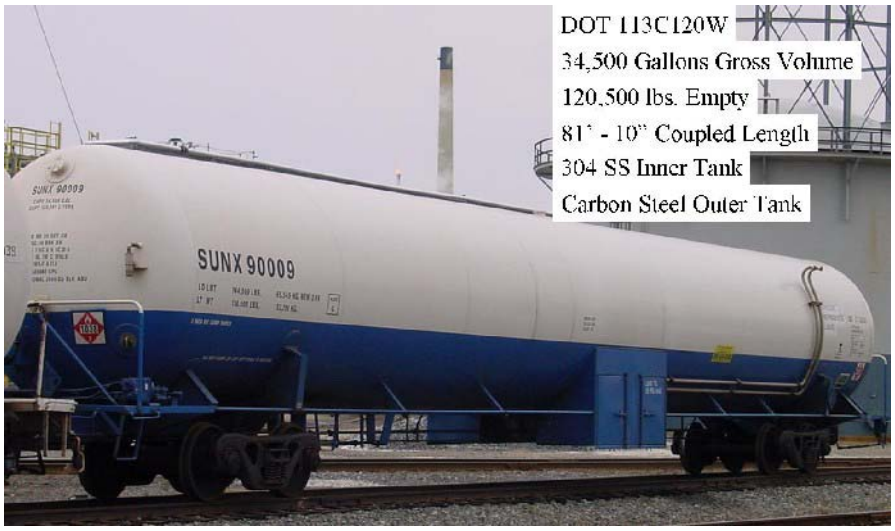


"C" Tank Cars:

Class DOT-113C120W tank cars began to be constructed in the 1970's and are the most common tank cars now used for cryogenic ethylene service. The rail weight limit is 263,000 pounds with a tare weight in the 117,000 to 120,000 pounds range.

The water capacity on these cars is nominally 33,000 gallons, which allows for a payload of approximately 28,500 to 29,000 gallons of cryogenic ethylene. Recently built cars have a gross volume of 34,500 gallons and a net cryogenic ethylene capacity of up to 144,000 pounds (30,380 gallons).

Class DOT-113C tank cars are equipped with one or dual pressure relief valves and dual rupture discs.



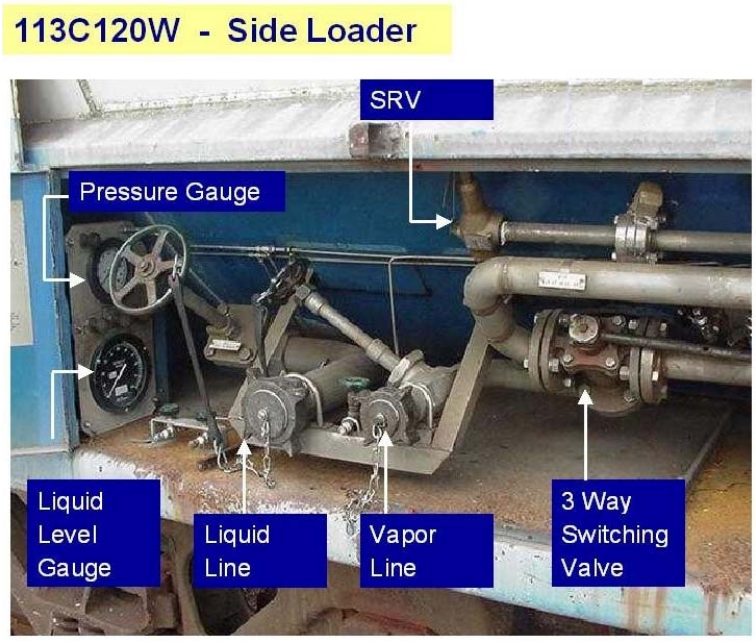
"C" Tank Cars (note that location of side cabinets may vary)

5.1.5.3 Location of Valves, Gauges, and Fittings

Except for some class DOT-113D tank cars (described above), the valves and fittings for loading and unloading, and the pressure relief devices, are located in

cabinets on both sides. In some cases, only one of the two cabinets contains the pressure relief devices, and is identified by the exhaust (vent) stack coming out of the cabinet and reaching the top of the tank car.

> ***Suggestion:***
> *It may be advisable to consider steps to deter unauthorized entry of the cabinet doors. There may be multiple methods to accomplish this goal. One option is to use a cable seal to secure the cabinet doors.*



Major Valves and Fittings

Vent stack

5.1.5.3.1 Pressure Relief Devices

Each class DOT-113 tank car has at least one rupture disc and one pressure relief valve.

Many tank cars have two rupture disc assemblies and two pressure relief valves connected to the tank through a crossover (or three-way) valve. In this case, only one set of pressure relief devices is operational at a time. The other serves as a back up and is immediately available by throwing the crossover valve.

Rupture discs and crossover valve

Pressure relief valves and crossover valve

5.1.5.3.2 Rupture Discs

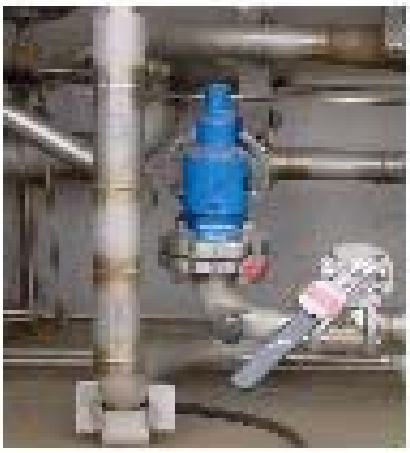
The nominal disc burst pressure is 100% of the tank test pressure (equals 120 psig for a class DOT-113C120W tank car). Each rupture disc must be replaced every 12 months, and the replacement date must be marked on the tank car near the pressure relief valve information (49 CFR §173.319(e)(4)).

Rupture Disc

5.1.5.3.3 Pressure Relief Valves

The start-to-discharge pressure for a pressure relief valve on a typical DOT-113 tank car is 75 psig. The vapor tight pressure is 60 psig. Additional information on pressure relief valves may be found at 49 CFR §179.401-1.

Pressure relief valves and alternate pressure relief valves must be tested every five years (49 CFR §173.319 (e)(5)).



Pressure Relief Valve

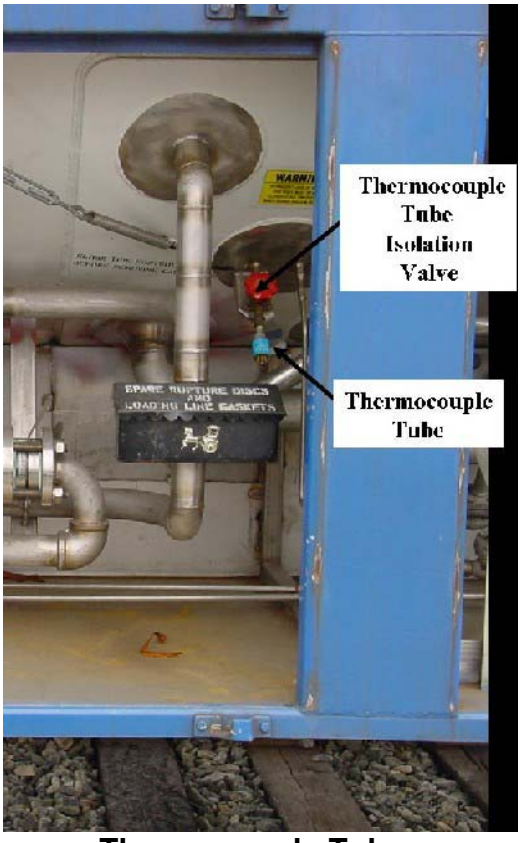
5.1.5.3.4 Gauges

Class DOT-113 tank cars must be equipped with the means to determine the liquid level. The most commonly used devices include a liquid-level gauge or provisions to use a portable gauge (49 CFR §179.400).

Class DOT-113 tank cars must also be equipped with a gauge to determine the vapor pressure on the tank (49 CFR §179.400).

These tank cars must also have a vacuum thermocouple tube to measure vacuum level in the annular space with an external device. The general requirements for measuring vacuum may be found at 49 CFR §173.319(b)(2).

Pressure and Liquid Level Gauge



Thermocouple Tube

5.1.6 Tank Car Operations

5.1.6.1 General Information

The general requirements for the transportation of cryogenic ethylene in tank cars are located in 49 CFR §173.319.

5.1.6.2 Filling

The amount of cryogenic ethylene loaded in a tank car is determined based on its *"maximum permitted filling density"* authorized by regulations (49 CFR §173.319(a)(2)). The amount of cryogenic ethylene loaded into a tank car must be determined to verify that the tank car has not been filled to a level in excess of its limits. The weight of any tank car loaded with cryogenic ethylene must be checked by the use of a scale before shipping (49 CFR §173.319 (a)(2)).

5.1.6.3 Shipping Pressure

The maximum allowable shipping pressure for a class DOT-113C tank car when offered for transportation is 10 psig (49 CFR §173.319 (d)(2)).

Special Note:
DOT- E 12039 permits a maximum shipping pressure of 20 psig for a class DOT-113C tank car, provided that the daily pressure rise is no more than 2.5 psig.

The maximum allowable shipping pressure on a class DOT-113D tank car is always 20 psig (49 CFR §173.319 (d)(2)).

For the return trip, the tank car must be unloaded to the maximum extent practicable (49 CFR §171.8).

CAUTION:
Unloading the tank car to the lowest practicable level (in most cases, where the liquid level gauge reads less than one inch and the pressure gauge reads less than 10 psig) helps avoid a pressure-related incident during the return trip.

5.1.6.4 Daily Pressure Rise

Each tank car shipment must be monitored to determine the average daily pressure rise. The consignee must note the pressure of the tank car when received and communicate this with the shipper in order for the shipper to determine the daily pressure rise (49 CFR §173.319 (e)(1)).

If the daily pressure rise has exceeded the 3 psig limit, the tank car must be taken out of service and a thermal integrity test must be performed (49 CFR §173.319 (e)(2)(i) & (ii)).

Special Note:
DOT-E 12039 limits the pressure rise on some shipments to 2.5 psig per day.

5.1.6.5 Transit Time

Cryogenic ethylene gains pressure in transit (typically 1 to 2 pounds per day in a tank car). Whenever the consignee has not received a tank car within 20 days from the date of the shipment, the shipper must notify the Bureau of Explosives (BOE) (49 CFR §173.319 (a)(3)).

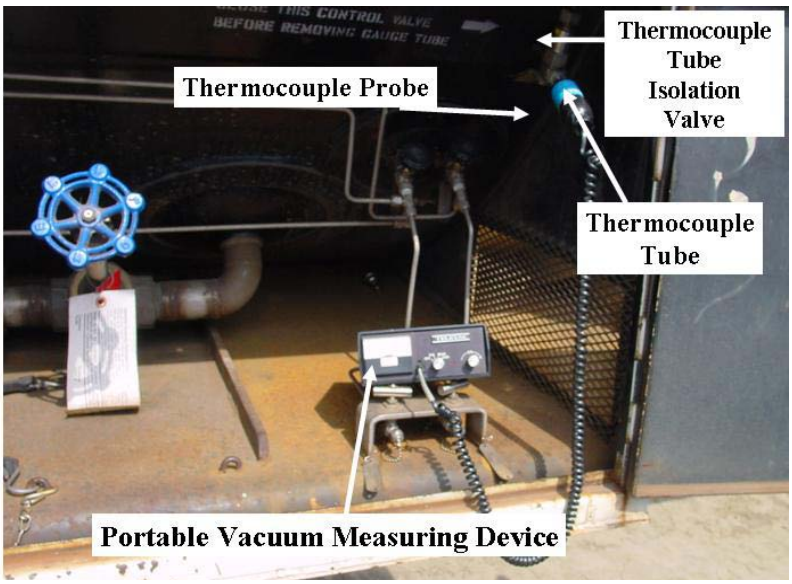
The 20-day time limit was calculated on an average daily pressure rise of 3 psig and the pressure relief valve setting of 75 psig (49 CFR §173.319(e)(1)).

Example:
If shipping pressure is 10 psig and 20 day travel time x 3 psig per day = 60 psig
10 psig + 60 psig = 70 psig (PRV set-to-discharge pressure is 75 psig.)

5.1.6.6 Vacuum

The vacuum reading in the annular space of the tank car must be less than 75 microns of mercury before the tank car can be offered for transportation (49 CFR §173.319 (b)(2)).

Suggestion:
It can be helpful for the consignee to take and record a vacuum reading in microns of the annular space and communicate it with the shipper so the shipper can monitor the vacuum integrity.



Reading vacuum with portable vacuum measuring device

5.2 Cargo Tanks

5.2.1 Regulations

Cryogenic ethylene is transported in specially built cargo tanks. These cargo tanks are insulated, and some are vacuum-jacketed, to keep cryogenic ethylene in a liquid state. The general requirements for transporting cryogenic ethylene in cargo tanks may be found in 49 CFR §173.318. The construction requirements for cargo tanks may be found in 49 CFR §178.338.

MC-338 Cargo Tank (non-vacuum jacketed)

MC-338 Cargo Tank (vacuum jacketed)

5.2.2 Design and Construction

Cryogenic ethylene is transported in DOT specification MC-338 cargo tanks. Some are constructed as insulated tanks with a metal jacket; others are constructed as a tank-within-a-tank. The space between the inner and outer layers is insulated either with perlite, wrapped fiberglass, foam or similar material and, in the tank-within-a-tank design, is under a vacuum. The insulation and vacuum reduce heat transfer from the outside, allowing the cryogenic ethylene to remain in

a liquid state. Each cargo tank is protected by one or more pressure relief valves and/or one or more rupture (frangible) discs.

5.2.3 Operations

Each cargo tank transporting cryogenic ethylene must be in compliance with all applicable regulations, including markings and placards, the amount of material loaded, temperature and pressure of lading, one way travel time, pressure relief valve retest, and rupture disc change out.

5.2.4 Hazard Communications

5.2.4.1 Marking

Each cargo tank transporting cryogenic ethylene must be legibly marked on both sides and both ends with "Ethylene, Refrigerated Liquid" (49 CFR §172.328(b)). The cargo tank must also have the identification number "1038" on both sides and both ends (49 CFR §172.332). The identification number is usually incorporated into the placard.

Placard and Proper Shipping Name Marking

Cargo tanks, in addition, must have their "one way travel time" (OWTT) marked on the tank on the right side near the front (49 CFR §183.318(g)).

One Way Travel Time (OWTT) Marking

5.2.4.2 Placarding

Each cargo tank must be placarded on both sides and both ends with the "flammable gas" placard (49 CFR §172.504). The identification number may be displayed on the placard (49 CFR §172.332(c)).

"Flammable gas" placard with identification number

5.2.4.3 Shipping Papers

Each shipment of cryogenic ethylene must have a shipping paper describing it as "ETHYLENE, REFRIGERATED LIQUID, 2.1, UN1038," and some indication of the total quantity, such as "1 cargo tank" (CT), as appropriate.

Example of shipping description

```
1 CT
ETHYLENE, REFRIGERATED LIQUID
2.1//UN1038
```

5.2.4.4 Exemptions/Approvals

DOT grants exemptions for certain activities not otherwise authorized by regulation (49 CFR §107.101). Where exemptions are granted, there must be a demonstration that a level of safety for the exempt activity equivalent to that required by the regulation is maintained.

At present time there are no exemptions governing the transportation of cryogenic ethylene in cargo tanks.

5.2.4.5 Inspections

Prior to offering the cargo tank for transportation, the shipper must ensure that the cargo tank is in proper condition (49 CFR §173.22), including proper pressure and temperature levels (49 CFR 173.318(e)).

An example of an Inspection Checklist for Cargo Tanks is located in Appendix 2.

5.2.5 Cargo Tank Construction

5.2.5.1 General Information

DOT MC-338 cargo tanks are of special design so that cryogenic ethylene remains in a liquid state during transportation to the consignee. DOT MC-338 cargo tanks are insulated tanks having a stainless steel or aluminum tank and a steel or aluminum jacket. The design may or may not include a vacuum in the annular space. The following section relates only to those items that are unique to DOT MC-338 cargo tanks.

5.2.5.2 Design and Construction

DOT MC-338 cargo tanks are designed for specific loading and shipping temperatures and have certain materials and fitting requirements (49 CFR §173.318 and 49 CFR §178.338).

Typical features of an MC-338 cargo tank are listed below (49 CFR §178.338-1):

Inner Tank

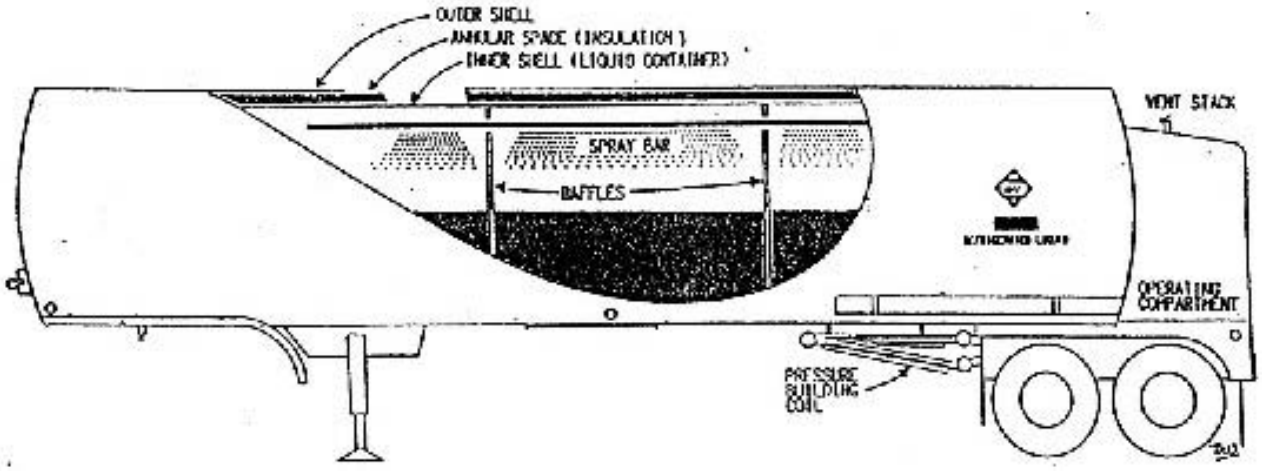
Thickness:	0.110” (minimum)
Material:	Aluminum or stainless steel

Outer Jacket

	Vacuum	No Vacuum
Stainless steel	0.0428”	0.0269”
Low Carbon Mild Steel	0.0946”	0.0677”
Aluminum	0.125”	0.1000”

Insulation

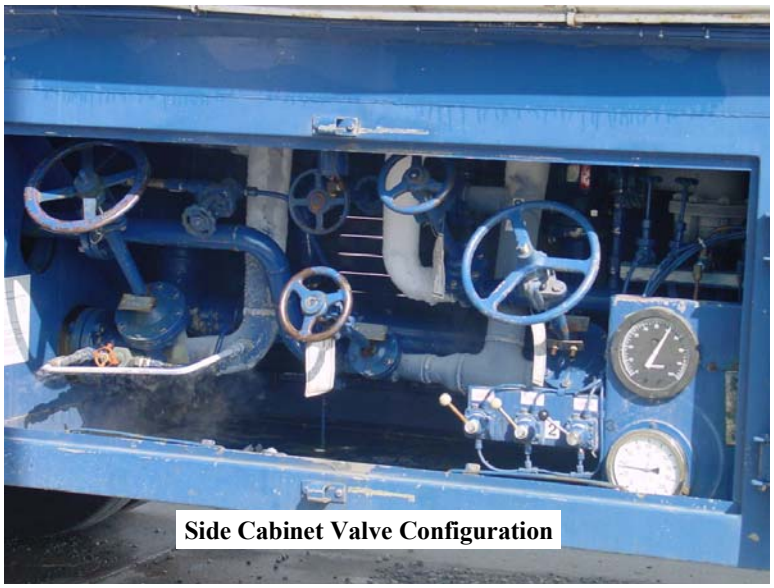
Perlite, wrapped fiberglass, or similar material such as polyurethane foam.



Cutaway Drawing of Cargo Tank
(Courtesy of Jack B. Kelley, Inc.)

5.2.5.3 Location of Valves, Gauges, and Fittings

The valves and fittings for loading and unloading, and the pressure relief devices, are located in a cabinet on either the side or rear end of the cargo tank. Locations of valves and fittings in the cargo tank cabinets will vary by manufacturer.



Side Cabinet Valve Configuration

Cabinet at End of Cargo Tank

5.2.5.3.1 Pressure Relief Devices

Each MC-338 cargo tank has a primary system of one or more pressure relief valves, and a secondary system of one or more rupture (frangible) discs or pressure relief valves (49 CFR §173.318(b)(1)(i)(A-B)).

5.2.5.3.2 Rupture Discs

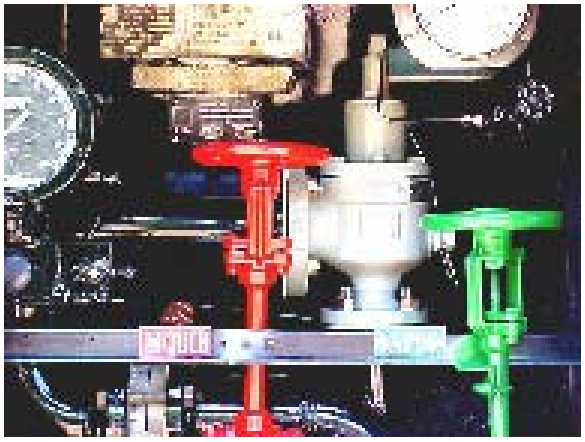
The normal disc burst pressure is between 130% and 150% of the tank design pressure. This would be between 91 and 105 psig for a typical 70 psig design pressure cargo tank (49 CFR 173.318(b)(4)(1)(B)). To determine disc burst pressure, read the number on the disc tag.

Rupture Disc

5.2.5.3.3 Pressure Relief Valves

The start-to-discharge pressure for a pressure relief valve on a typical MC-338 cargo tank is 70 psig. This information may be found on the cargo tank's specification plate and the pressure relief valve's specification plate or tag. Additional information on pressure relief valves may be found at 49 CFR §173.318(b) and §178.338-8.

Pressure relief valve



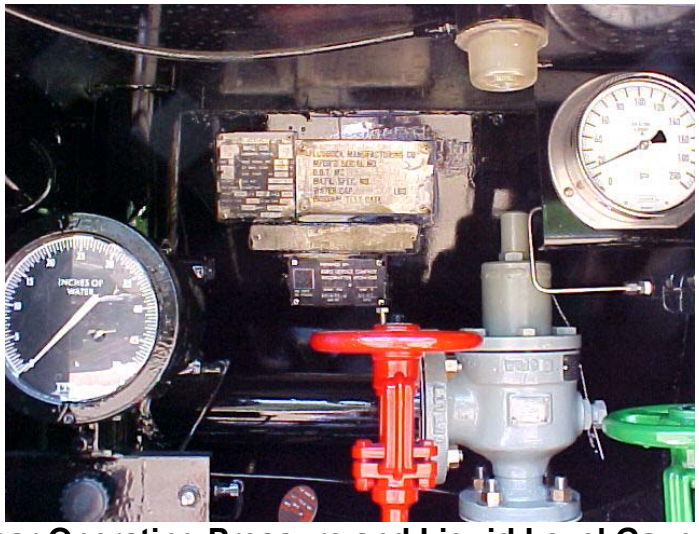
Pressure relief valve in cabinet

5.2.5.3.4 Gauges

Unless a cargo tank is intended to be filled by weight, it must be equipped with one or more gauging devices that accurately indicate the maximum permitted liquid level (49 CFR §178.338-14).

A pressure gauge is located in the rear or side cabinet for use by the operator when transferring cryogenic ethylene. Additionally, each cargo tank must be provided with a suitable pressure gauge indicating the lading pressure and located on the front of the cargo tank so that the driver can read it using the rear-view mirror. Each gauge must have a reference mark at the cargo tank design pressure or the set pressure of the pressure relief valve or pressure control valve, whichever is lowest (49 CFR §178.338-14).

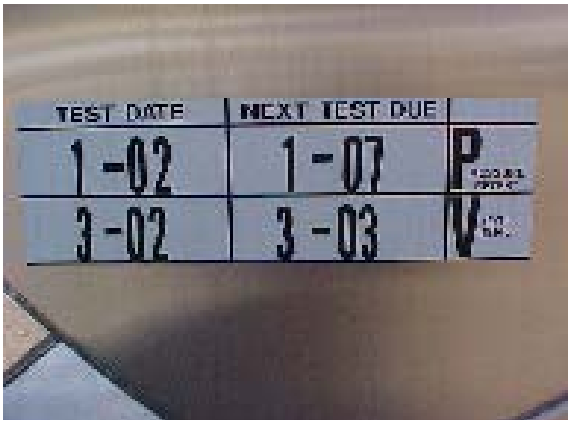
Front-Mounted Pressure Gauge



Rear Operating Pressure and Liquid Level Gauges

5.2.5.3.5 Requalification

Each MC-338 cargo tank must have an annual external visual (V) inspection and have a pressure (P) test every 5 years (49 CFR §180.407(c)).



Test date markings

5.2.6 Cargo Tank Operations

5.2.6.1 General Information

The general requirements for the transportation of cryogenic ethylene in cargo tanks can be located in 49 CFR §173.318.

5.2.6.2 Filling

The amount of cryogenic ethylene loaded in a container is determined based on the "*maximum permitted filling density*" authorized by regulations for cargo tanks (49 CFR §173.318(f)(2)). The amount of cryogenic ethylene loaded into a cargo tank must be determined to verify that the cargo tank has not been filled to a level in excess of its limits. The amount can be determined either by means of a gauge or weighing on a scale (49 CFR §173.318(c)).

5.2.6.3 Filling Temperature

A cargo tank may not be loaded with cryogenic ethylene colder than its design service temperature (49CFR 173.318(a)(1)).

5.2.6.4 Holding Time

The cargo tank must be tested to determine its "holding time." This is a test of the effectiveness of the tank and insulation systems.

The "holding time" is determined by testing as the time that will elapse from loading until the cargo tank pressure, under equilibrium conditions, reaches the level of the lowest pressure control valve or pressure relief valve setting. The holding time measured by this test is adjusted for an ambient temperature of 85^{o}F. This is the "rated holding time" (RHT) for the tank. The "marked rated holding time" (MRHT) displayed on or adjacent to the specification plate may not exceed the RHT (49 CFR 173.318(g)(3)).

5.2.6.5 Transit Time

Cryogenic ethylene gains pressure in transit. There are safety limits as to how long a shipment may remain in transportation. This is defined as the "one-way travel time" (49 CFR §173.318(g)).

The "one-way travel time" is a calculated value for the time (in hours) that the cargo tank may transport a flammable cryogenic liquid. The jacket of a cargo tank must be marked on its right side near the front, in letters and numbers at least two inches high, "One Way Travel Time ___ hrs". The blank is filled in with a number indicating the one-way travel time of the cargo tank for the flammable cryogenic liquid to be transported. The abbreviation "OWTT" may also be used.

For cargo tanks the "one-way travel time" is defined as follows (49 CFR 173.318(g)(2)):

If MRHT is 72 hours or less	OWTT = (MRHT – 24)/2
If MRHT is greater than 72 hours	OWTT = MRHT – 48

The actual holding time for a cargo tank must be determined after each shipment. If it is determined that the actual holding time is less than 90% of the MRHT of the cargo tank, the cargo tank may not be refilled until it is restored to its MRHT or the cargo tank is re-marked with the reduced holding time determined by this examination 49 CFR §173.318(g)(3).

The driver of a cargo tank transporting cryogenic ethylene must avoid unnecessary delays during transportation. For each shipment, the driver is required to make a written record of the cargo tank's pressure and ambient (outside) temperature (49 CFR §177.840(h))

- At the start of each trip;
- Immediately before and after any manual venting;
- At least once every five hours; and
- At the destination point.

An example of a Trip Pressure Report for Cargo Tanks may be found in Appendix 3.

5.2.6.6 Shipping Pressure

"A flammable cryogenic liquid in a cargo tank at the start of travel must be at a temperature sufficiently cold that the pressure setting of the pressure control valve or the required pressure relief valve, whichever is lower, will not be reached in less time than the marked rated holding time for the cryogenic liquid" (49 CFR §173.318[e]). Lowering the cargo tank's pressure to below 15 psig at the start of travel may also help meet this requirement.

CAUTION:
Unloading the cargo tank to the lowest practicable level (in most cases, where the liquid level gauge reads "zero" and the pressure gauge reads less than 10 psig) helps avoid a pressure-related incident during the return trip.

5.3 ISO Containers (Isotainer)

5.3.1 Regulations

Cryogenic ethylene is transported in specially built ISO containers, or "Isotainers." These "Isotainers" are vacuum-jacketed to keep cryogenic ethylene in a liquid state. The design, construction and operating requirements may be found in 49 CFR §172.101. "Isotainers" may be designed, constructed and operated as portable tanks in accordance with Special Provisions T75 and TP5 of the Hazardous Materials Tables (49 CFR §172.101) and 49 CFR §178.277 and 178.274 (UN portable tanks). "Isotainers" have also been constructed in accordance with the requirements in 49 CFR §178.338 (cargo tanks) and operated under an exemption, such as DOT-E 11186, found in Appendix 4.

A copy of DOT Exemption 11186 may be found in Appendix 4.

5.3.2 Design and Construction

Cryogenic ethylene is transported in International Maritime Organization (IMO) Type 7 “Isotainers.” All are constructed as a tank-within-a-tank. The space between the inner and outer tanks is insulated with either perlite or wrapped fiberglass or similar material and is under a vacuum. The insulation and vacuum reduce heat transfer from the outside, allowing the cryogenic ethylene to remain in a liquid state. Each “Isotainer” is protected by three pressure relief valves.

“Isotainer”

5.3.3 Operations

Each “Isotainer” transporting cryogenic ethylene must be in compliance with all applicable regulations, including markings and placards, the amount of material loaded, one-way travel time, vacuum level, and pressure relief valve retest.

5.3.4 Hazard Communications

5.3.4.1 Marking

Each “Isotainer” transporting cryogenic ethylene must be legibly marked on both sides with “Ethylene, Refrigerated Liquid” (49 CFR §172.326(a)). The “Isotainer” must also have the identification number “1038” on both sides and both ends (49 CFR §172.332). The identification number is usually incorporated into the placard.

Placard and Proper Shipping Name Marking

Additionally, if an “Isotainer” is operating under the provisions of a DOT Exemption, it must be marked as required by the specific exemption.

5.3.4.2 Placarding

Each “Isotainer” must be placarded on both sides and both ends with the “flammable gas” placard (49 CFR §172.504). The identification number may be displayed on the placard (49 CFR §172.332(c)).

Flammable Gas Placard with Identification Number

5.3.4.3 Shipping Papers

Each shipment of cryogenic ethylene must have a shipping paper describing it as “ETHYLENE, REFRIGERATED LIQUID, 2.1, UN1038”, and some indication of the total quantity, such as “1 tank” (1 TK), as appropriate.

For any shipment made under the provisions of a DOT Exemption, the shipping papers must state the exemption number, as "DOT-E" followed by the number of the exemption, unless specifically excepted in the exemption.

Example of shipping description

```
1 TK
ETHYLENE, REFRIGERATED LIQUID
2.1//UN1038
```

Additionally, shipments of cryogenic ethylene in "Isotainers" transported on vessels must have the notation "ONE WAY TRAVEL TIME ___ HOURS", with the number of hours filled in (DOT-E 11186, item 10(b)(2)).

5.3.4.4 Exemptions/Approvals

DOT grants exemptions for certain activities not otherwise authorized by regulation (49 CFR §107.101). Where exemptions are granted, there must be a demonstration that a level of safety for the exempt activity is maintained. DOT-E 11186 authorizes the use of "Isotainers" to transport cryogenic ethylene.

"Isotainer" exemption stenciling

5.3.4.5 Inspections

Prior to offering the "Isotainer" for transportation, the shipper must ensure that the "Isotainer" is in proper condition (49 CFR §173.22).

An example of an Inspection Checklist for "Isotainers" may be found in Appendix 7.

5.3.5 "Isotainer" Construction

5.3.5.1 General Information

"Isotainers" are of special design so that cryogenic ethylene remains in a liquid state during transportation to the consignee. Isotainers are designed as a tank-within-a-tank, and typically have a stainless steel, 9% nickel steel, or aluminum inner tank and a carbon steel outer tank 49 CFR §178.338. A vacuum is drawn on the annular space between the inner and outer tanks. The following sections relate only to those items that are unique to "Isotainers."

5.3.5.2 Design and Construction

"Isotainers" are designed for specific loading and shipping temperatures and have certain materials and fitting requirements (DOT-E 11186, 49 CFR §178.277, 49 CFR §173.318, 49 CFR §178.338).

Typical features of an "Isotainer" are listed below (49 CFR §178.338-1):

Inner Tank (minimum thickness):

Stainless steel	0.110"

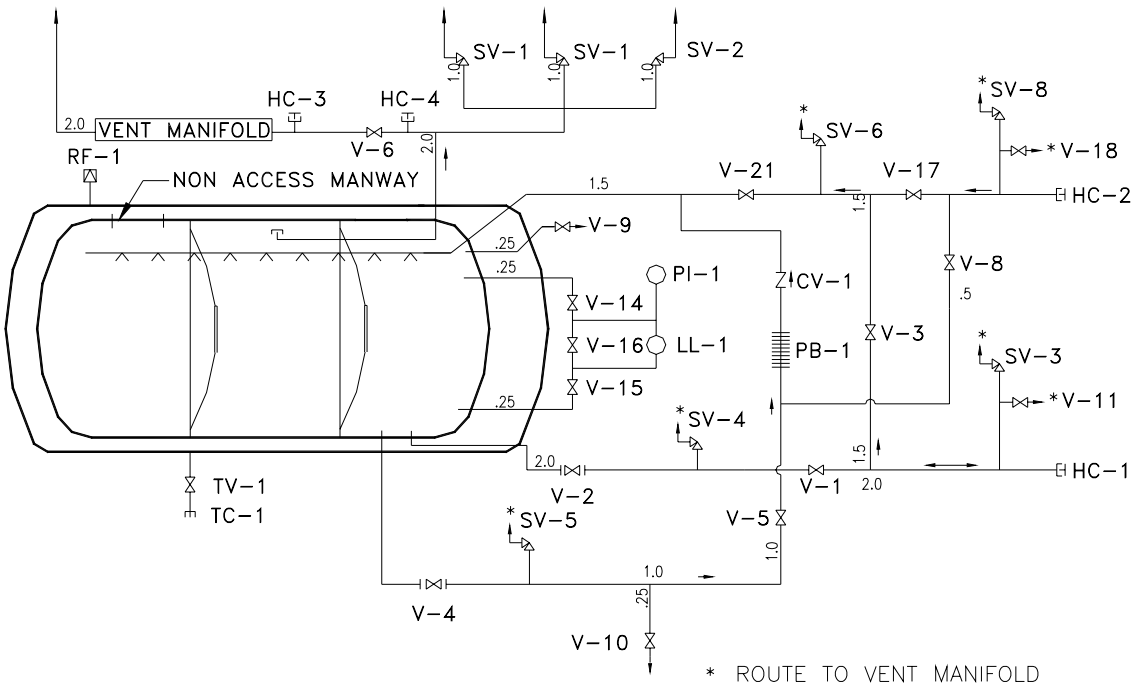
Outer Tank (minimum thickness):

Stainless steel	0.0428"
Low Carbon Mild Steel	0.0946"
Aluminum	0.125"

Insulation:

Perlite or wrapped fiberglass or similar material.

FLOW SCHEMATIC



LEGEND		
DESIG	DESCRIPTION	SIZE
V-1	FILL & DRAIN VALVE, GLOBE	2"
V-2	FILL/DRAIN FIRE BLOCK VALVE, BALL	2"
V-3	TOP FILL VALVE, GLOBE	1-1/2"
V-4	PBU FIRE BLOCK VALVE, BALL	1"
V-5	PRESSURE BUILD VALVE, GLOBE	1"
V-6	MANUAL VENT VALVE, GLOBE	2"
V-8	PRESSURE FORCE FEED	1/2"
V-9	FULL TRYCOCK VALVE, GLOBE	1/4"
V-10	LIQUID SAMPLE VALVE, GLOBE	1/4"
V-11	FILL LINE BLEED VALVE, BALL	3/8"
V-14	LP ISOLATION VALVE, NEEDLE	1/4"
V-15	PANEL ISOLATION VALVE, NEEDLE	1/4"
V-16	LL GAUGE EQUALIZER VALVE, NEEDLE	1/4"
V-17	PUMP RECIRCULATION VALVE, GLOBE	1 1/2"
V-18	RECIRC LINE BLEED VALVE, BALL	3/8"
V-21	GAS RECOVERY VALVE, GLOBE	1-1/2"
TC-1	THERMOCOUPLE	-----
TV-1	TC-1 ISOLATION VALVE	1/8"

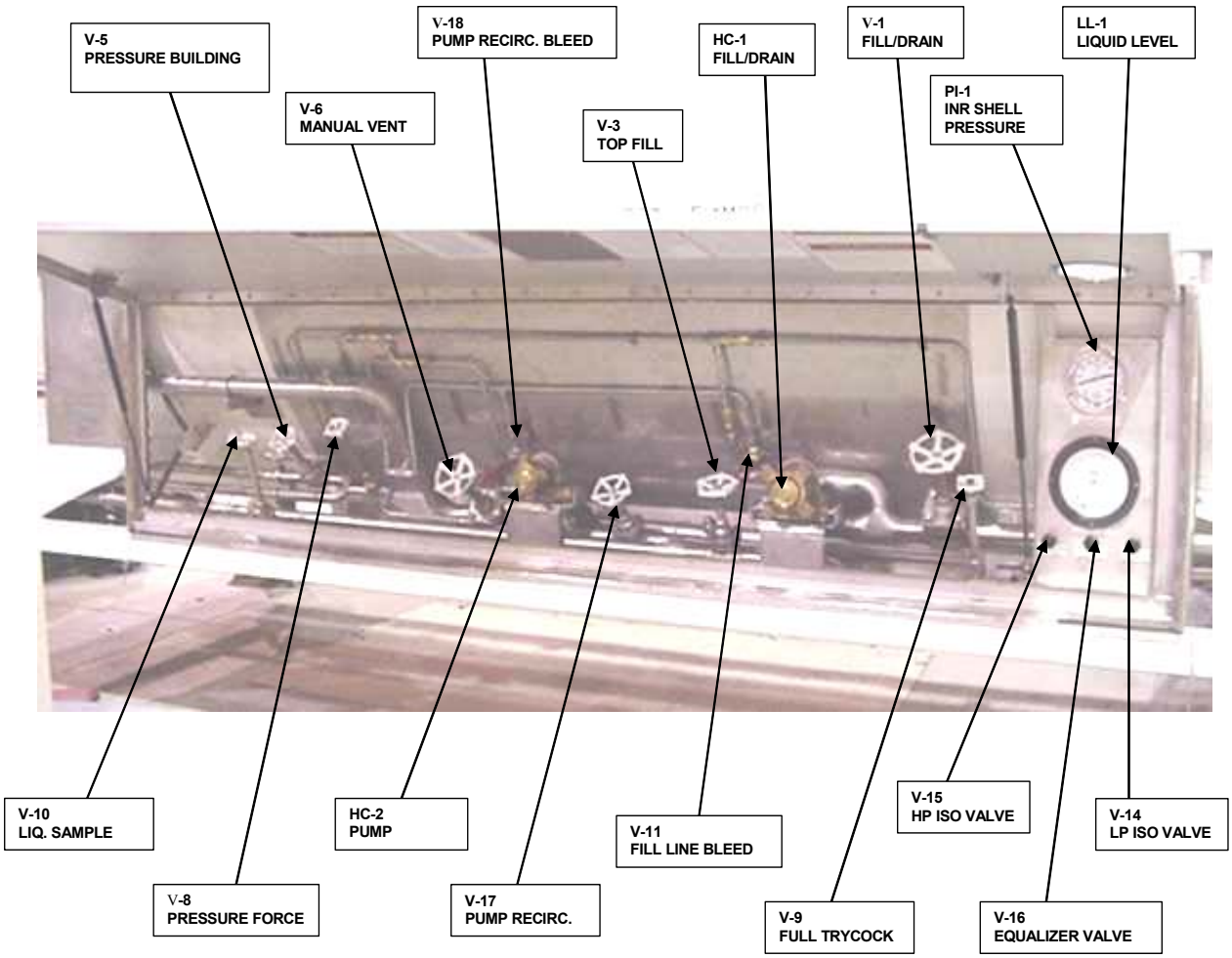
LEGEND		
DESIG	DESCRIPTION	SIZE
RF-1	JACKET VACUUM RELIEF, O-RING	5 I.D.
SV-1	INNER VESSEL RELIEF VALVE, 150 PSI	1 "
SV-2	IV SECONDARY RELIEF VALVE, 200 PSI	1 "
SV-3	FILL LINE RELIEF VALVE, SET @ 325 PSI	1/2"
SV-4	FIRE BLOCK RELIEF VALVE, SET @ 325 PSI	1/2"
SV-5	PB FIRE BLOCK RELIEF VALVE SET @ 325 PSI	1/2"
SV-6	VAPOR RECOVERY RELIEF VALVE SET @ 325 PSI	1/2"
SV-8	RECIRC LINE RELIEF VALVE SET @ 325 PSI	1/2"
CV-1	CHECK VALVE	1-1/2"
PI-1	VESSEL PRESSURE GAUGE, 0-200 PSI	4 1/2" DIAL
LL-1	LIQUID LEVEL GAUGE, 0-100" W.C.	6" DIAL
PB-1	PRESSURE BUILDUP COIL	-----
HC-1	FILL & DRAIN CONN.	2-1/2"
HC-2	PUMP RECIRCULATION CONN.	1 1/2"
HC-3	COMPONENT VENT	1"
HC-4	GENERATOR (FUTURE USE)	1"

11808321

Example Flow Schematic of an "Isotainer"
(Courtesy of Chart Industries)

5.3.5.3 Location of Valves, Gauges, and Fittings

The valves and fittings for loading and unloading are located in a cabinet on either side or either end of the "Isotainer."



Location of valves, gauges and fittings in "Isotainer" cabinet

The liquid fill and vapor recovery connections on "Isotainers" are generally acme-thread female connections. (The 2" Fisher M252 female connection is a common example). The shipper and other companies involved should communicate in advance so there are appropriate connections to match those on the "Isotainer."

5.3.5.3.1 Pressure Relief Devices

"Isotainers" do not have rupture discs; they have a set of three pressure relief valves. The start-to-discharge pressure for a pressure relief valve on a typical "Isotainer" in cryogenic ethylene service is 150 psig. Additional information on

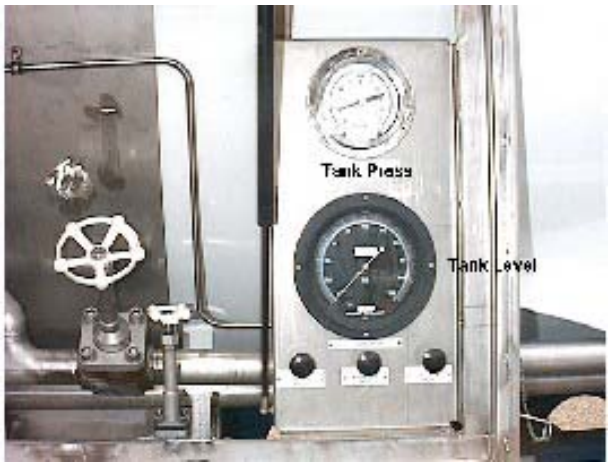
pressure relief valves may be found at 49 CFR §173.318(b) and 49 CFR §178.338-8.

Pressure relief valves

5.3.5.3.2 Gauges

Unless an "Isotainer" is intended to be filled by weight, it must be equipped with one or more gauging devices which accurately indicate the maximum permitted liquid level (49 CFR §178.338-14).

Pressure and liquid level gauges are located in the cabinet for use by the operator when transferring cryogenic ethylene. The pressure gauge must have a reference mark at the "Isotainer" design pressure or the set pressure of the pressure relief valve or pressure control valve, whichever is lowest (49 CFR §178.338-14).



Pressure and liquid level gauges

5.3.5.3.3 Requalification

Each "Isotainer" in cryogenic ethylene service must have an annual external visual inspection and have a pressure test every 5 years (DOT Exemption DOT-E 11186 and 49 CFR Part 180).

5.3.6 "Isotainer" Operations

5.3.6.1 General Information

The general requirements for the transportation of cryogenic ethylene in "Isotainers" may be located in 49 CFR §173.318 and DOT-E 11186.

5.3.6.2 Filling

The amount of cryogenic ethylene loaded in an "Isotainer" is determined based on "*maximum permitted filling density*" authorized by exemption for "Isotainers" (DOT-E11186). The amount of cryogenic ethylene loaded into an "Isotainer" must be determined to verify that the "Isotainer" has not been filled to a level in excess of its limits. The amount can be determined either by means of a gauge or weighing on a scale (49 CFR §173.318(c)).

5.3.6.3 Filling Temperature

An "Isotainer" may not be loaded with cryogenic ethylene colder than its design service temperature (49 CFR §173.318(a)(1)).

5.3.6.4 Holding Time

The "Isotainer" must be tested to determine its "holding time." This is a test of the effectiveness of the "Isotainer" and its insulation system (49 CFR §173.31(g)(3)).

The "holding time" is determined by testing as the time that will elapse from loading until the pressure, under equilibrium conditions, reaches the level of the lowest pressure control valve or pressure relief valve setting. The holding time measured by this test is adjusted for an ambient temperature of 85^{o} F. This is the "rated holding time" (RHT) for the "Isotainer." The "marked rated holding time" (MRHT) displayed on or adjacent to the specification plate may not exceed the RHT (49 CFR §173.318(g)(3)).

5.3.6.5 Transit Time

Cryogenic ethylene gains pressure in transit. There are safety limits as to how long a shipment may remain in transportation. This is defined as the "one-way travel time" (DOT-E11186, item 10(b)(2)).

One-way travel time (OWTT) is a calculated value for the time (in hours) that the "Isotainer" may transport a flammable cryogenic liquid. The jacket of an "Isotainer" must be marked on its right side near the front, in letters and numbers at least two inches high, "One-Way-Travel-Time ___ hrs". The blank is filled in with a number indicating the one-way travel time of the "Isotainer" for the flammable cryogenic liquid to be transported. The abbreviation "OWTT" may be used in place of the words "One-Way-Travel-Time."

For "Isotainers" the "one way travel time" is defined as: OWTT = MRHT - 24

"OWTT ___ hrs." Stencil

The actual holding time for each "Isotainer" must be determined after each shipment. If it is determined that the actual holding time is less than 90% of the MRHT of the "Isotainer," the "Isotainer" may not be refilled until it is restored to its MRHT or the "Isotainer" is re-marked with the reduced holding time determined by this examination (DOT-E 11186, item 7(c)(3)).

A written record of the "Isotainer's" pressure and ambient (outside) temperature at the following times must be prepared for each shipment (49 CFR §177.840(h) and DOT-E 11186):

- At the start of each trip;
- Immediately before and after any manual venting;
- At least once every five hours by highway, or every 24 hours for an "Isotainer" aboard a vessel; and
- At the destination point.

5.3.6.6 Shipping Pressure

An "Isotainer" containing cryogenic ethylene cannot be shipped unless the pressure of the lading is less than or equal to that used to calculate the MRHT, and the OWTT is greater than or equal to the elapsed time between the start and termination of travel (DOT E-11186, item 10(b)(1)(i)).

5.3.6.7 Movement by Rail

"Isotainers" may not be transported by rail in container-on-flat-car (COFC) or trailer-on-flat-car (TOFC) service unless the rail carrier has an approval issued by the Federal Railroad Administration (49 CFR §174.63).

6.0 MAINTENANCE AND REPAIR OF TRANSPORT EQUIPMENT

6.1 General Information

Most transportation equipment for cryogenic ethylene consists of a liquid-containing pressure vessel, insulation, and an outer tank or jacket. In many cases the insulation space is evacuated.

- Tank cars for cryogenic ethylene are always vacuum insulated (49 CFR §179.400-(3)(a)(2)).
- Cargo tanks for cryogenic ethylene may be either vacuum insulated or non-vacuum insulated (49 CFR §173.318 and §178.338).
- "Isotainers" for cryogenic ethylene are always vacuum insulated (49 CFR §178.338 and DOT-E 11186).

The maintenance and repair guidelines offered in this publication focus on the cryogenic and other unique aspects of the containers for cryogenic liquid ethylene. This section does not discuss railroad running gear and air brake maintenance, highway trailer automotive component maintenance, or ISO frame and corner casting maintenance.

CAUTION:

Consult owner/operator's company policies for working in a cryogenic or gaseous ethylene environment. Unless the tank and piping have been purged with nitrogen or other suitable gas, any gas (pressure) released from the car or any isolated piping, whether by normal action of a pressure relief valve (vessel primary or line safety), rupture disc or by the removal of a component for repair / replacement, will be ethylene.

Cryogenic ethylene being stored or transported in a tank presents the same hazards of low temperature and product under pressure that the more common cryogenic industrial gases such as nitrogen and argon present, but has the additional hazard of being flammable.

Follow the owner / operator's company policies for working in an actual or potential, cryogenic or gaseous, ethylene environment.

Please refer to Section 3 of this document and review the shipper's Material Safety Data Sheet (MSDS) for "Ethylene, Refrigerated Liquid" before handling cryogenic ethylene or operating transportation equipment.

6.2 Periodic Maintenance

6.2.1 Annular Space Vacuum

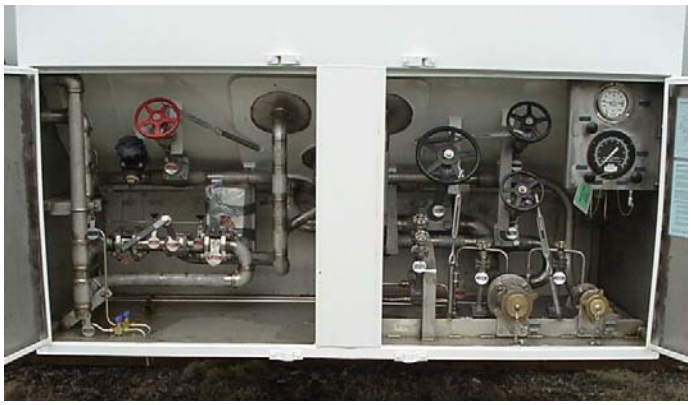
Regular monitoring and vacuum pumping as necessary of the annular space (see Section 6.3 below) promotes optimal thermal performance of a vacuum insulated container.

6.2.2 External (Control) Piping

Known leaks or deficiencies in the piping or piping components must be repaired or replaced prior to putting the container into service in accordance with 49 CFR §173.22, 49 CFR §173.22a, 49 CFR §173.24, 49 CFR §173.24b, 49 CFR §173.31, and 49 CFR §173.32.

Typical Cargo Tank Cabinet Piping

"Isotainer" Cabinet



Typical Tank Car Cabinet Piping

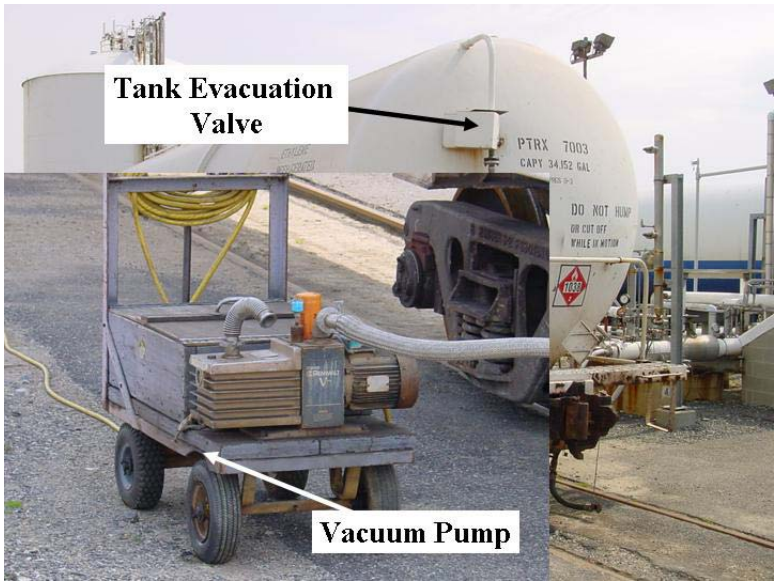
A leak or flow of cryogenic ethylene usually leaves a telltale frost path. However, frost from condensation may be present on the piping of a recently filled container for several days after filling. Frost on a line may indicate a leak somewhere downstream that is allowing the flow of cryogenic ethylene. An ethylene leak may also be detected by its faint, sweet odor.

6.3 Ad Hoc Maintenance

6.3.1 Re-evacuating a Vacuum Insulated Container

As the vacuum in the annular space deteriorates, heat is absorbed into the inner vessel at an increasing rate, resulting in a decrease in hold time and increase in daily pressure rise. A very high quality vacuum in the annular space helps maintain thermal performance.

Re-establishing vacuum is not typically done in the field. See your equipment maintenance manual, repair shop, or other appropriate resource.

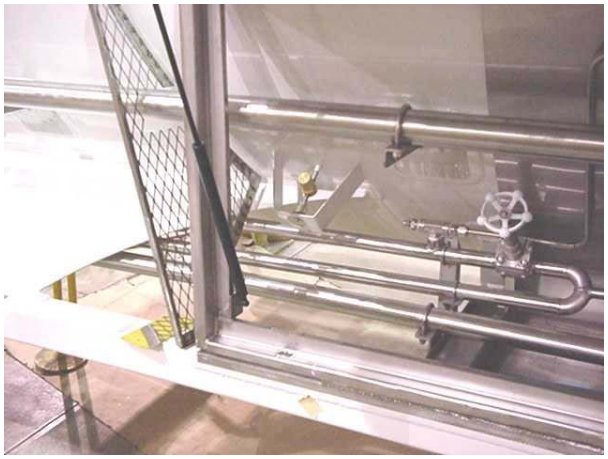


Vacuum pump in operation

6.3.2 Replacing Thermocouple Tube

The thermocouple tube is a device that allows measurement of the vacuum in the annular space using the appropriate vacuum gauging equipment. The vacuum is measured as "microns of mercury absolute," usually abbreviated as "microns." One micron of mercury equals 1/1000 millimeter of mercury.

Thermocouple tube connection and isolation valve for tank car



Thermocouple tube connection for "Isotainer"

Keeping the thermocouple tube shut-off valve closed (except when reading the gauge), helps avoid potential leakage from the joint between tube and valve.

An effective way to take vacuum measurements is to take the measurements first with the valve closed, then again with the valve open. A substantial drop in the gauge reading (i.e., from 100 microns to 50 microns) when the valve is opened may indicate a leak between the thermocouple tube and the shut-off valve. (A leak in the thermocouple tube would result in a similar drop in the gauge reading, but is a less

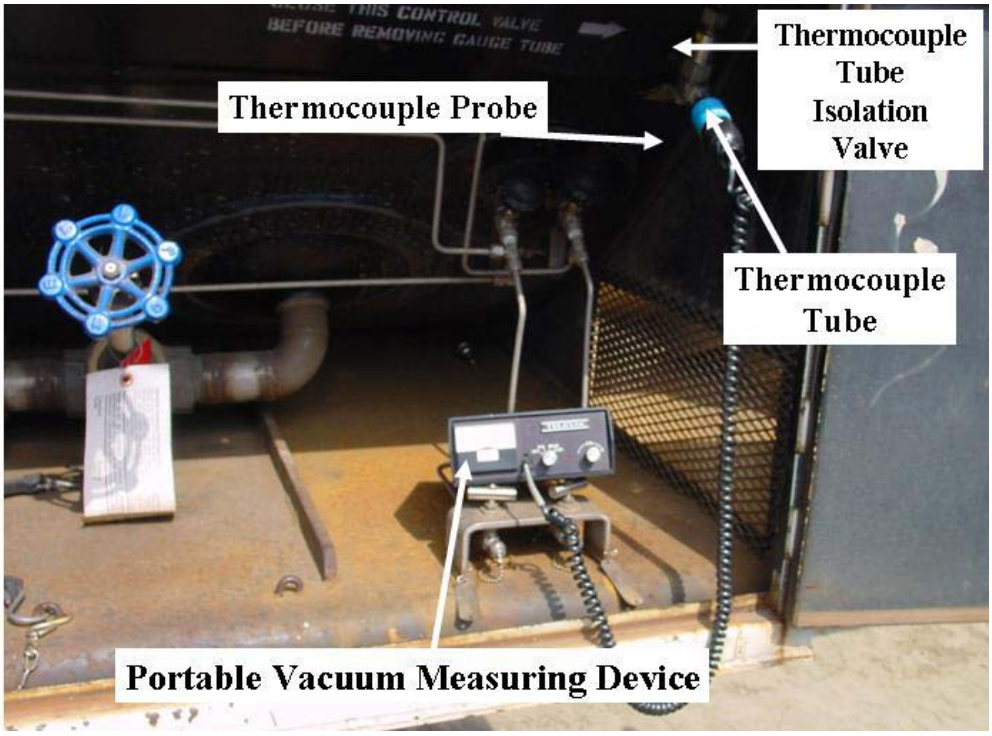
likely occurrence.) If there is a leak, the threaded joint on the thermocouple tube may be re-sealed using an appropriate vacuum thread sealant.

> ***Note:***
> *Appropriate vacuum thread sealants are specifically designed for a high-quality vacuum environment, and may require a curing time. Polytetrafluoroethylene (PTFE) tapes or wraps are not appropriate vacuum thread sealants.*

Keep the gauge connected to the tube until the reading on the gauge has stabilized–on analog meters this is when the needle stops moving. On digital meters, this is when the reading on the gauge is steady. Be patient to get an accurate reading.

> ***CAUTION:***
> ***Experience suggests that under sub-zero weather conditions, vacuum readings may be difficult to obtain.***

With a newly installed thermocouple tube, take a reading with the shut-off valve open, then close the valve, wait for an appropriate period and take another reading. If the second reading is appreciably higher, it is very likely there is a leak between the tube and the valve.



Reading vacuum with portable vacuum measuring device

A faulty thermocouple tube will not move off atmosphere when read. If the tube will not move off atmosphere or appears to be defective, take appropriate corrective action steps, such as replacing it with a new tube.

To replace the thermocouple tube, close the gauge shut-off valve. Next, unscrew the old tube, being very careful not to disturb the joints on each side of the valve. (It may be necessary to hold the valve with a wrench). Thoroughly clean the threads on the valve and on the tube, then put thread sealant on the new tube (starting one thread from the open end) and screw it into the valve. Again, be careful of the isolation valve joints.

Generally, reference tubes that read a prescribed vacuum level (micron reading) are available from the tube and gauge manufacturer. The reference tube can be useful to calibrate or verify the calibration of the vacuum gauge.

6.3.3 Replacing Pressure Relief Valves

CAUTION:
In all cases, operators must exercise appropriate caution and take into consideration the flammability, pressure, cryogenic hazards and other characteristics of cryogenic ethylene.

6.3.3.1 Inner Vessel Pressure Relief Valve

For a tank with a dual pressure relief valve assembly, the 'leg' with the deficient pressure relief valve may be isolated via the crossover (or three-way) valve. It may be possible to isolate the bad leg by this means while cryogenic ethylene is flowing through the deficient pressure relief valve, depending on the conditions. This may be done when the inner vessel pressure has come down to a reasonable value, which will not result in the pressure relief valve on the other leg relieving. The operator may then use the vent valve or the vapor return valve to bring the pressure down further, and/or to control it at a given point.

If the tank is not equipped with dual pressure relief valves, the tank can be purged of ethylene using an inert gas. Follow the tank owner/operator's policy for working in an ethylene environment.

Pressure relief valve

Dual pressure relief valve assembly

6.3.3.2 Inner Vessel Rupture Discs

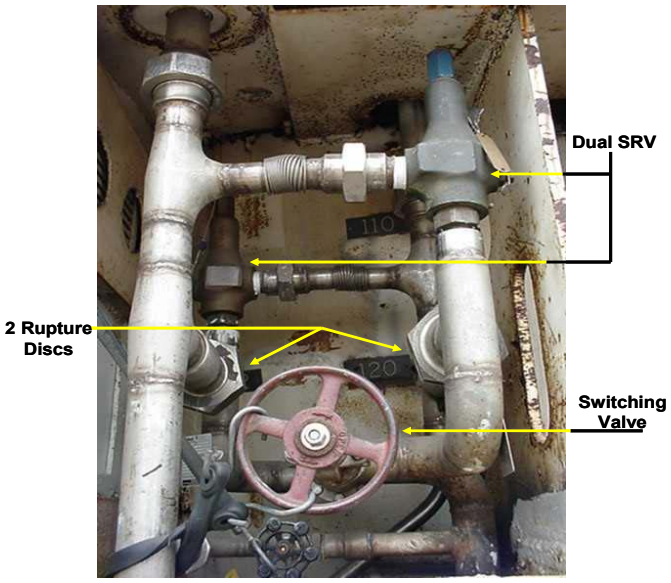
The type of rupture (frangible) disc(s) and holder(s) on the tank can vary widely.

In a dual rupture (frangible) disk configuration, the 'leg' of the dual rupture disc arrangement with the deficient disc may be isolated via the crossover (or three-way) valve. It may be possible to isolate the deficient leg by this means while product is flowing through the deficient rupture disc, depending on the conditions. This may be done when the inner vessel pressure has decreased to a value that will not result in the rupture disc on the other leg relieving. The operator may then use the vent valve or the vapor return valve to bring the pressure down further, and/or to control it at a given point.

If the crossover (or three-way) valve is not used, blow down the pressure in the inner vessel and use an inert gas to purge the inner vessel of ethylene.

113C120W Dual Rupture Disc Assembly

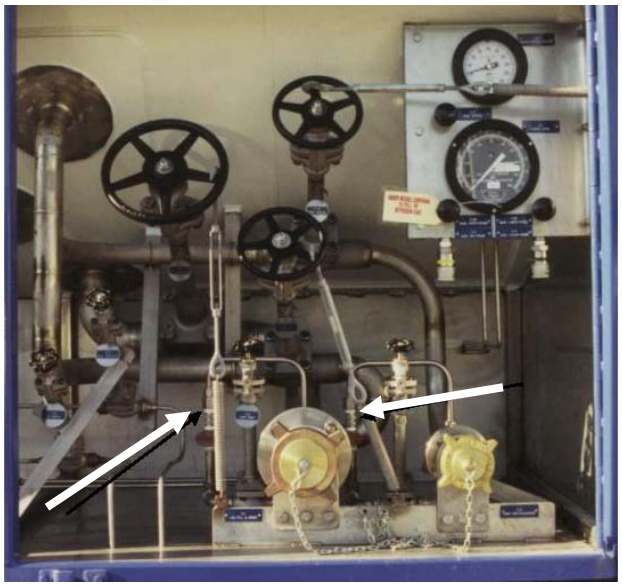
113D120W Safety Valve and Rupture Disc Assembly



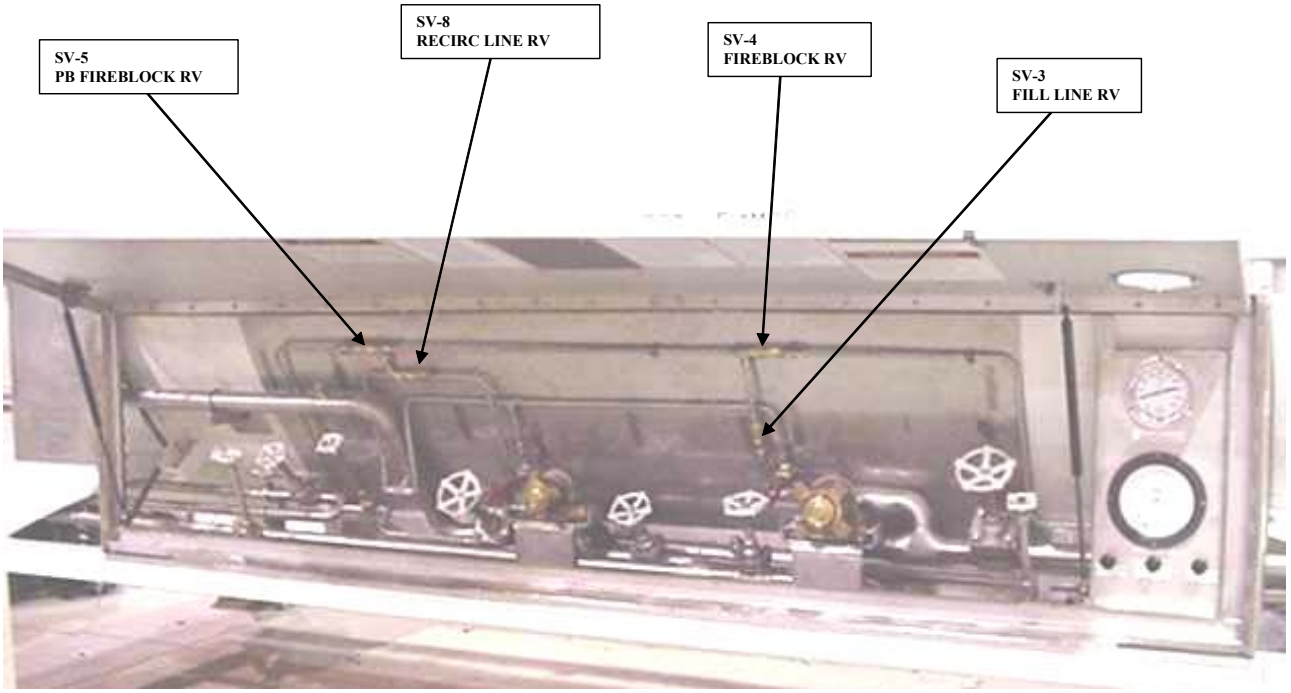
Dual rupture (frangible) disc assemblies with crossover (or three-way) valve

6.3.3.3 Line Pressure Relief Valves (Thermal Reliefs)

Line pressure relief valves or thermal relief devices are required in sections of piping where cryogenic ethylene can be trapped between two closed valves, regulators or other components. (49 CFR §173.318(9)(i) and 49 CFR §179.400-20(e)). The trapped liquid will expand as the ambient temperature warms it and will burst the isolated section of pipe if relief is not provided.



Close-up of Line Pressure Relief Valves



"Isotainer" Cabinet Line Pressure Relief Valves

6.4 Miscellaneous Issues

6.4.1 Assessing Vacuum in the Field

If there is a known or visible breach in the outer tank, the vacuum in the annular space has been lost. Otherwise, to determine whether a vacuum insulated container still has a vacuum, and a vacuum gauge is not available, several techniques are available including:

- Observe the outside surface of the outer tank for frost – either a uniform frost over most of the surface or isolated "frost spots." Loss of vacuum will result in a cooler outer tank.
- Take temperature measurements of the skin temperature of the outer tank. It should normally be within 10 degrees F° of the ambient temperature.
- Check whether the outer tank's safety heads are in place; they are held in place by vacuum. If they are in place, use moderate hand force to check whether they are firmly in place. If there is no vacuum, they will move easily; if there is vacuum, they will be difficult to move. Safety heads are typically located along the top of the tank, or on the upper part of the heads. They are usually four to six inches in diameter and seal against one or two (concentric) O-rings.

Location of safety heads

- Compare the rate of pressure rise compared to previous measurements when the tank had a good vacuum. If the annular space has lost vacuum, the inner vessel's daily pressure rise will be greater. See Table 1 below for an illustration of estimated rate of pressure rise for a tank car starting at a certain pressure with a certain vacuum.

TABLE 1: Estimated rate of pressure rise for a tank car starting at a certain pressure with a certain vacuum.

(Values should be considered approximate)

Elapsed time (in days) to 70 psig for a stationary ethylene car at a given pressure and vacuum level							
		Vacuum (microns)					
		1	10	50	75	100	No Vacuum
Pressure In Tank Car (psig)	15	*88.2*	*25.6*	*17.4*	*15.0*	*13.2*	*2.0*
	20	*72.6*	*21.1*	*14.3*	*12.4*	*10.9*	*1.6*
	25	*64.0*	*18.6*	*12.6*	*10.9*	*9.6*	*1.5*
	30	*55.9*	*16.2*	*11.0*	*9.5*	*8.4*	*1.3*
	35	*48.2*	*14.0*	*9.5*	*8.2*	*7.2*	*1.1*
	40	*40.7*	*11.8*	*8.0*	*6.9*	*6.1*	*0.9*
	45	*33.4*	*9.7*	*6.6*	*5.7*	*5.0*	*0.8*
	50	*26.2*	*7.6*	*5.2*	*4.5*	*3.9*	*0.6*
	55	*19.3*	*5.6*	*3.8*	*3.3*	*2.9*	*0.4*
	60	*12.7*	*3.6*	*2.5*	*2.2*	*1.9*	*0.3*
	65	*6.3*	*1.8*	*1.2*	*1.1*	*1.0*	*0.1*
	70	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*

Example: tank arrives at 35 psig inner tank pressure and 50 microns vacuum level
inner tank pressure will rise to 70 psig in 9.5 days

Notes:

- Pressure relief valves are allowed by regulation to start-to-discharge at 72 psi and could begin at less than 72 psi
- This chart is applicable to CHART Industries built Model SR-601 and SR-602 Tank cars
  (SUNX-90000-90004: SR-601) (APHX-2012-2015: SR-601)
  (SUNX-90005-90014: SR-602) (HLEX-60201-60207: SR-602)
- This table assumes the tank car is stationary. Moving the car once a day or once every 2-3 days may reduce the pressure in the car and extend the time it takes to reach 75 psig
- No Vacuum = 760,000 microns = 1 atmosphere

6.4.2 Assessing Load in the Field

To assess whether an ethylene container is loaded or unloaded, there are indicators available in addition to the liquid level gauge, shipping papers and weight of the container. For example:

- If there are bottom liquid fill / withdrawal lines, liquid sample lines, pressure building liquid lines or other bottom liquid connections on the container, crack open the valve(s) in one of those bottom lines and observe whether liquid product flows out.
    - No liquid flow suggests the container is empty (unless the lines are frozen, clogged or otherwise obstructed).
- If the container is upside down, test one of the top or vapor lines.
- If the container is on its side, the top or bottom lines would be expected to yield liquid if the container is loaded more than half full.

6.4.3 Monitoring Containers That Are Delayed in Transportation

During normal operation of the cryogenic container, sloshing of the liquid in the container will aid in keeping the pressure down. Excessive container pressure, resulting in the pressure relief valve releasing the excess gas, may result when the container is left to store cryogenic product for a period of time such that normal evaporation of product, due to heat leak into the liquid container, builds pressure in the container.

Excessive pressure may also occur on vacuum insulated containers when the vacuum on the container is degraded or lost. On non-vacuum insulated containers, damage to the insulation may result in increased pressure rise.

In an emergency situation, some temporary options for handling a container with increasing pressure (in advance of, or as a more permanent response is being developed) are:

- Moving the container to mix the liquid in it (“sloshing the liquid”), which generally mixes colder, denser liquid with warmer vapor, condensing some of the vapor and lowering the pressure.
- Using the vent valve or vapor recovery connection to vent gas from the top of the container in order to lower the pressure, to: atmosphere, a flare, or a vapor recovery system.

TABLE 2: Issue Analysis

This table shows some, but not all, commonly observed issues regarding equipment repair and maintenance. Selected common, possible explanations and responses are outlined below. They are not meant to be presented in any particular sequence, nor are they intended to be exhaustive. Issue analysis is dependent on site-specific conditions.

ISSUE	Possible Explanation(s) Include:	Possible Response (s)
Primary inner vessel pressure relief valve activates	Excessive container pressure	Check container pressure (See below) (See Explanatory Note #1)
	Faulty pressure relief valve	Examine and replace (See Section 6 – Maintenance & Repair)
Secondary inner vessel pressure relief device activates	Excessive container pressure, plus faulty primary pressure relief valve	Check container pressure Check primary pressure relief valve (See Explanatory Note #2)
	Faulty, corroded or damaged secondary inner vessel pressure relief device	Examine and replace (See Section 6 – Maintenance & Repair)
Inaccurate vacuum reading	Thermocouple tube shut-off valve closed and leak at joint	(See Explanatory Note #3)
	Deficient thermocouple tube	Replace (See Section 6 – Maintenance & Repair) (See Explanatory Note #4)
	Time to re-evacuate container	(See Section 6.3.1 – Maintenance & Repair)
Liquid level gauge reads too high	Leak in gas side piping	Find and fix leak
	Gauge calibration off	See Explanatory Note #5
	Faulty gauge	See Explanatory Note #5
Liquid level gauge reads too low	By-pass valve not closed	Close valve. See Explanatory Note #5
	Leak in liquid side piping	Find and fix leak
	Gauge calibration off	See Explanatory Note #5
	Faulty gauge	See Explanatory Note #5
Pressure gauge reads too high	Faulty gauge	Recalibrate or replace gauge
Pressure gauge reads too low	Isolation valve closed	Open valve
	Leak in gauge piping	Find and fix leak
	Faulty gauge	Recalibrate or replace gauge See Section 6
Thermal relief device (Line safety) activates	Liquid or very cold gas trapped between closed valves or connections	None. (That is why the device is installed)
	Faulty or improperly set or calibrated device	Recalibrate/reset or replace

Note: Numbered Explanatory Notes Follow This Table

EXPLANATORY NOTES

1. During normal operation of the container, sloshing of the liquid in the container will tend to keep the pressure down.
Excessive container pressure, resulting in the pressure relief valve having to release the excess gas, may result when the container is left to store cryogenic product for such a time that normal evaporation of product, due to heat leak into the liquid container, builds pressure in the unit. Excessive pressure may also occur on vacuum insulated containers when the vacuum on the container is degraded or lost. (See Section 6). On non-vacuum insulated containers, damage to the insulation may result in increased pressure rise.

In circumstances where it is appropriate to attempt to relieve container pressure, a container with increasing pressure may be temporarily aided by:

- Moving the container to 'slosh the liquid,' which generally mixes colder, denser liquid with warmer vapor, condensing some of the vapor and lowering the pressure.
- Using the vent valve or vapor recovery connection to vent gas from the top of the container to: atmosphere, a flare, or a vapor recovery system, in order to lower the pressure.
- Other appropriate methods.

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2. If the secondary pressure relief device activates due to over pressure, it indicates that pressure has gone higher than the primary pressure relief valve set pressure (which is not possible if the primary pressure relief valve is operating properly), or, the secondary pressure relief device has failed prematurely due to corrosion, other mechanical damage, or perhaps is defective for some other reason. See Section 6.3.3.1 or 6.3.3.2 regarding replacement of pressure relief valves or rupture (frangible) discs. The crossover (or three-way) valve may be used to isolate the appropriate secondary pressure relief device.

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3. On vacuum insulated containers, the thermocouple tube shut-off valve is kept closed except when reading the gauge, because the joint between tube and valve is a potential source of leakage.

Vacuum measurements are generally taken first with the valve closed, then again with the valve open. A substantial drop in the gauge reading (i.e., from 100 microns to 50 microns) when the valve is opened may indicate a leak between the thermocouple tube and the shut-off valve. (A leak in the thermocouple tube would result in a similar drop in the gauge reading, but is a less likely occurrence.) If there is a leak, the threaded joint on the thermocouple tube may be re-sealed using an appropriate vacuum thread sealant.

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4. A faulty thermocouple tube will not move off atmosphere when read. If the tube will not move off atmosphere or appears to be defective, replace it with a new tube.

Replacement of a thermocouple tube generally begins by closing the gauge shut-off valve. The old tube is unscrewed, being very careful not to disturb the joints on each side of the valve. (It may be necessary to hold the valve with a tool such as a wrench). Thoroughly clean the threads on the valve and on the tube. Thread sealant on the new or repaired tube (starting one thread from the open end) helps create a seal. The tube is screwed into the valve. Again, be careful of the isolation valve joints. Check for leakage.

Note: Appropriate vacuum thread sealants are specifically designed for a high-quality vacuum environment, and may require a curing time. Polytetrafluoro-ethylene (PTFE) tapes or wraps are not appropriate vacuum thread sealants.

Generally, reference tubes that read a prescribed vacuum level (micron reading) are available from the tube and gauge manufacturer. The reference tube can be useful to calibrate or verify the calibration of the vacuum gauge.

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5. The liquid level gauge senses the difference in pressure between the top of the inner vessel and the bottom of the inner vessel. Calculations, resulting in a table of contents versus Inches of Water Column can determine pressure difference, which is interpreted as quantity of liquid in the inner vessel. (Note that anything producing a false differential pressure at the gauge or that upsetting the assumptions on which the calculations are based will yield inaccurate calculations.

The discussion below applies only when the container is in an upright and normal orientation. A closed by-pass valve helps the liquid level gauge to function normally.

Leaks in the lines to the gauge produce a false differential pressure at the gauge. (With no flow, the gas pressure in a line is the same at the inner vessel end and the outer vessel end.) If there is a leak in the piping outside the vacuum jacket (outer tank), there is flow from the inner vessel to the leak, and where there is flow there is always a pressure drop. If there is a leak in the gas side piping, the result is a lower than true pressure at the gas side of the gauge, while the liquid side pressure is true. This means the gauge feels a greater pressure difference than it should, and this makes the gauge read higher than it should.

If there is a leak in the liquid side piping, the reverse occurs. The pressure difference and gauge readings are lower than they should be, making the gauge read lower than it should.

A leak in the liquid side gauge piping will often cause frost to appear where the line leaves the vacuum jacket (outer tank). If the by-pass valve is partially open, the differential pressure on the gauge will be partially eliminated by flow through the by-pass, resulting in a low reading or no reading at all.

It is possible for the gauge itself to fail. If the gauge reads zero inches of water column when its two shut-offs are closed and its by-pass valve is open, the gauge is probably operating properly. If it will not move to zero inches of water column, repair or replacement is appropriate.

When pressure in the inner vessel is changed quickly, the position of the liquid in the line will change and cause the gauge reading to change. An increase in pressure causes a decrease in reading and vice versa. This condition generally corrects itself in a short time.

7.0 TRANSPORTATION EMERGENCY RESPONSE

An unplanned release of cryogenic ethylene may never occur if the chemical is stored and handled properly at all times. However, as with all hazardous materials, emergency incidents are always possible. Therefore, sufficient emergency response capability is a necessity for responsible management.

Preparation in advance of an emergency situation is the most important part of an effective emergency response plan. A thorough plan should consider possible consequences of a cryogenic ethylene transportation incident.

Responding to a transportation incident can be complex. There are many considerations, and the steps to be taken and the sequence of those steps is largely dependent on fact-specific circumstances. Some basic considerations are noted in this section. They are neither intended to be prescriptive nor exhaustive.

7.1 Notification

If a transportation incident involving cryogenic ethylene does occur, the Chemical Transportation Emergency Center (CHEMTREC®) is available for immediate assistance. CHEMTREC® is a service of the American Chemistry Council and its members to provide assistance in hazardous materials incidents. It is recognized by the U.S. Department of Transportation as an information resource for transportation emergencies including hazardous materials.

CHEMTREC's® toll-free emergency assistance number is 1-800-424-9300. The CHEMTREC® center is staffed 24 hours a day, 7 days a week by trained emergency communicators.

Special Note:
Section 7 provides guidelines on emergency response. The shipper can be a very important resource during an incident. It may be important, helpful, or required to provide notice to the shipper of the incident by the emergency response telephone number located on the shipping paper.

7.2 Container Stopped or Delayed in Transit (Not Damaged and Not Leaking)

Occasionally, a shipment of cryogenic ethylene may be stopped delayed in transit. The movement of cryogenic ethylene in the container generally helps keep the pressure of material from increasing more than a few pounds per day.

Interruption in transportation of cryogenic ethylene, however, may allow pressure to build up. If a tank car is stopped for repairs for more than a day, periodically moving the tank car back and forth during the repair stop can help slow the pressure rise. Moving the container will generally mix the colder, denser liquid with warmer vapor, condensing some of the vapor and lowering the pressure. For a more detailed discussion, see also Section 6.4.3, "Monitoring Containers That Are Delayed in Transportation."

7.3 Container Not Damaged in a Transportation Accident, but is Leaking (Non-Accident Release)

Where the container is not damaged but is leaking, initial steps are generally taken to address the leak. General considerations are discussed in this section.

7.3.1 Personal Protective Equipment

See Section 3.1, "Personal Protective Equipment." The size, pressure and volume of release are key factors in the type and amount of personal protective equipment to be used. PPE may include:

- Self-container breathing apparatus (SCBA)
- Fire retardant clothing (i.e. fire-retardant coveralls or turn-out gear)
- Insulated gloves

Special Note:
At time of publication, there are no insulated gloves designed to allow hands to be put into a cryogenic liquid. Insulated gloves provide only short-term protection from accidental contact.

Emergency responders at scene of non-accident release

7.3.2 Fittings in Cabinet

If the cabinet is equipped with a diagram, the diagram can be used to help determine the source of the leak. Leaks in the cabinet may come from a variety of sources, including the following items mentioned below.

An example diagram of tank car cabinet fittings may be found in Appendix 8.

Valves are potential sources of leaks, and may need to be closed or tightened. An appropriate strap, such as an elastic cord or turnbuckle, may be attached to the valve handle to prevent movement.

Caps are another potential source of leaks, and may need to be closed or tightened. If a leak continues, the gasket may need to be replaced.

CAUTION:
The valve should be closed and undamaged before the valve cap is removed.

The packing gland nut may need tightening and/or additional packing to stop leaks.

If a broken line prior to the valve is the source of a leak, it may be useful to plug, freeze patch, or crimp the line to slow or stop the leak. The container may need to have its contents transferred and to be depressurized prior to offering it for transportation.

Special Note:
For tank cars, FRA movement approval must be obtained prior to offering any car in transportation that has had field repairs.

Close-up of clamp used to close line

7.3.3 Releasing from Vent Stack

A container may also release cryogenic ethylene from its vent stack. Information on the container's expected and actual pressure may be useful to help determine the appropriate course of action.

Vent stack

The shipper may be contacted to determine how long the container has been in transit and what would be the expected pressure of the container.

The actual container pressure may be checked and compared with the stenciled pressure of the pressure relief valve and rupture (frangible) disc. The pressure relief valve or the rupture (frangible) disc may be checked to determine whether they are releasing.

If the pressure relief valve is leaking and the actual container pressure is below the stenciled pressure:

- For containers equipped with dual pressure relief valves, the crossover (three-way) valve may be turned to activate the other device.
- For containers not equipped with dual pressure relief valves, the container's contents may need to be transferred in order for the valve to be replaced.

Pressure relief valve, with crossover (three-way) valve (arrow)

If the pressure relief valve is leaking and the actual container pressure is above stenciled pressure:

- The container may be isolated and allowed to vent until the pressure reduces and the pressure relief valve reseats to the closed position.
- The container may have lost vacuum insulation in the annular space.
- After the pressure relief valve reseats, the container may need to be vented or flared to reduce the pressure. The shipper should be consulted to determine the appropriate pressure.
- If the container is close to its origin or destination, the container may be moved to the facility for offloading. Depending on the particular circumstances, the container's contents may need to be transferred.

If the rupture (frangible) disc is releasing and the actual container pressure is below stenciled pressure:

- The crossover (three-way) valve may be turned to activate the other disc.

If the rupture (frangible) disc is releasing and the actual container pressure is above the stenciled pressure:

- The container may be isolated and allowed to vent until the pressure drops below the stenciled pressure.
- The shipper may be consulted to determine the appropriate pressure to operate the crossover (three-way) valve to activate the second rupture (frangible) disc.
- If the container is close to its origin or destination, container may be moved to the facility for offloading. Depending on the particular circumstances, the container's contents may need to be transferred.

7.4 Container Damaged in an Accident

7.4.1 Not Leaking

If the damaged container is not leaking, it should be examined to determine the type and extent of damage in order to take appropriate action. Dents, gouges and other damage may be visible. Damage to running gear, safety appliances, wheels, trucks and frame may not affect the integrity of the container.

The initial container pressure should be measured and compared to the stenciled pressure. The container pressure should also be measured and documented frequently, such as every thirty minutes or less, until the emergency is mitigated.

The container may be vacuum-jacketed and should be checked to determine that it has still has vacuum. If the vacuum insulation has been lost, container pressure may rise quickly. The container may need to be vented or flared and the contents transferred. (See Section 6.4.1, "Assessing Vacuum in the Field," for more information.)

Damage to the fitting cabinet may result in frost build-up and indicate a leak. This may be confirmed with air monitoring using a combustible gas indicator.

Overturned Car – Not Leaking

7.4.2 Leaking

A damaged container may be leaking from one of more sources:

If the container is leaking from a vent stack, the accident may have caused the container to over-pressure or, if vacuum-jacketed, to lose its vacuum. (Refer to Section 7.3.3 to help determine whether the discharging pressure relief devices can be isolated.)

If the container is leaking from the cabinet, refer to Section 7.3.3 to help determine the possible sources of the leak.

If the container is leaking from a hole in the tank, the area around the tank should be isolated. Mitigation methods and options for repair and/or transfer may be possible but are outside the scope of this document.

7.5 Mitigation

CAUTION:
The mitigation procedures discussed in this Section require specific training and should only be conducted by qualified emergency response personnel.

7.5.1 Vapor Flare for Cryogenic Ethylene

Flaring is an option when pressure in the container needs to be controlled. Pressure control may be necessitated by a number of events, such as loss of vacuum, too much residue, too long transit time, or contamination. In the cases listed above the pressure relief valve may be cycling between open and closed settings.

A vapor flare can be used to control the pressure long enough to get the container to the shipper or consignee to be off loaded, or to support transfer of contents in the field.

Vapor Flare for Cryogenic Ethylene

If a vapor flare is to be used, the following considerations may be useful:

- Examine the area above and around the work area where the flare is planned. Heat from the flare may dry out vegetation, and a ground fire may result.
- A grounded container minimizes static discharges.
- Setting up the flare an appropriate distance from the container minimizes risk of an undesirable fire.
- Consider wind direction, and set flare upwind or crosswind of the container if possible. The flaring operation should take into account the possibility that wind direction may change.
- Running the hoses from the container to the flare stack helps minimize static discharges.
- A check valve on the flare stack helps manage the flow of cryogenic ethylene.
- Pressure testing all hoses with an inert gas helps confirm tight connections, and purges air out of the hoses and flare stack.
- Lighting the pilot flame on the flare stack will initiate and maintain combustion of ethylene vapor.
- Monitoring container pressure throughout the process contributes to safe operation and allows the process to continue until the desired pressure is reached.
- If ice builds up on the flare stack, the flow volume should be reduced.
- When operations are completed, purge hoses and flare with an inert gas to remove any remaining cryogenic ethylene.
- Hoses may frost up due to the flow of cryogenic ethylene, and should be allowed to thaw before moving to prevent damage.

Liquid Flare for Cryogenic Ethylene

7.5.2 Liquid Flare for Cryogenic Ethylene

Liquid flare can be used when a vapor flare cannot control the pressure. The technique is similar to a vapor flare except that the flare pipe is placed horizontally, instead of vertically, and placed over a trench or a pit.

7.5.3 Container Transfer

Transfer of cryogenic ethylene is accomplished by using an inert gas to pressure liquid ethylene from the loaded container into the receiving container. Pressure on the receiving container is controlled using a vapor flare.

If the contents of a container are to be transferred, the following considerations may be useful:

- Examine the area above and around the work area where the flare is planned. Heat from the flare may dry out vegetation, and a ground fire may result.
- Chock or block containers to prevent movement during transfer.
- A grounded container minimizes static discharges.
- Make liquid connection between loaded container and receiving container to prepare for liquid transfer.
- Make vapor connection between receiving container and flare stack to control pressure in receiving container.
- Pressure testing all hoses with an inert gas helps confirm tight connections, and purges air out of the hoses and flare stack.
- Flaring the receiving container will maintain the vapor pressure as cryogenic ethylene is transferred into the receiving container (see section 7.5.1).
- Introducing an inert gas into the loaded container as needed helps maintain flow of cryogenic ethylene into the receiving container.
- Monitoring pressure and liquid level in both containers throughout the process contributes to safe operation and allows the process to continue until the desired pressures and levels are reached.
- When operations are completed, purging hoses and flare with an inert gas will help remove any remaining cryogenic ethylene.
- Hoses may frost up due to the flow of cryogenic ethylene liquid and vapor, and should be allowed to thaw before moving to prevent damage.

APPENDICES

Appendix 1: Example DOT Exemption DOT-E 12039 (From DOT website http://hazmat.dot.gov/exemptions)

U.S. Department of Transportation
Research and Special Programs Administration

400 Seventh St., S.W.
Washington, D.C. 20590

AUG 15 2003

DOT-E 12039
(FOURTH REVISION)

EXPIRATION DATE: July 31, 2005

(FOR RENEWAL, SEE 49 CFR § 107.109)

1. GRANTEE: Sunoco, Inc.
Marcus Hook, PA
(Former grantee: Sun Company, Inc.)

(See Appendix A to this exemption for a list of additional grantees)

2. PURPOSE AND LIMITATION:

a. This exemption authorizes the transportation in commerce of DOT 113C120W tank cars containing Ethylene, refrigerated liquid, at an internal pressure of 20 psig instead of the maximum 10 psig. This exemption provides no relief from any Hazardous Materials Regulations (HMR) other than as specifically stated herein.

b. The safety analyses performed in development of this exemption only considered the hazards and risks associated with transportation in commerce.

3. REGULATORY SYSTEM AFFECTED: 49 CFR Parts 106, 107 and 171-180.

4. REGULATIONS FROM WHICH EXEMPTED: 49 CFR § 173.319(d)(2) in that a maximum pressure, when offered for transportation, of 20 psig is not authorized, except as specified herein.

5. BASIS: This exemption is based on Sunoco, Inc.'s application dated August 11, 2003, submitted in accordance with § 107.109.

Appendix 1: Example DOT Exemption DOT-E 12039 (cont'd)

AUG 15 2003

6. HAZARDOUS MATERIALS (49 CFR § 172.101):

Hazardous Materials Description			
Proper Shipping Name	**Hazard Class/ Division**	**Identification Number**	**Packing Group**
Ethylene, refrigerated liquid *(cryogenic liquid)*	2.1	UN1038	N/A

7. SAFETY CONTROL MEASURES:

a. PACKAGINGS: Prescribed packagings are DOT Specification 113C120W tank cars.

b. TESTING: If the average daily pressure rises during any shipment and exceeds 2.5 psig per day, the tank must be tested for thermal integrity as specified in § 173.319(e)(2) prior to any subsequent shipments.

8. SPECIAL PROVISIONS:

a. Tank cars containing only the residue of product may not be offered for transportation above 10 psig.

b. MARKING: Each tank car must be marked "DOT-E 12039" in letters and numerals at least 4 inches high on a contrasting background above the DOT specification marks.

9. MODES OF TRANSPORTATION AUTHORIZED: Rail freight.

10. MODAL REQUIREMENTS: None as a requirement of this exemption.

11. COMPLIANCE: Failure by a person to comply with any of the following may result in suspension or revocation of this exemption and penalties prescribed by the Federal hazardous materials transportation law, 49 U.S.C. 5101 et seq:

- All terms and conditions prescribed in this exemption and the Hazardous Materials Regulations, 49 CFR Parts 171-180.
- Registration required by § 107.601 et seq., when applicable.

Appendix 1: Example DOT Exemption DOT-E 12039 (cont'd)

Continuation of DOT-E 12039 (4th Rev.) AUG 15 2003 Page 3

Each "Hazmat employee", as defined in § 171.8 who performs a function subject to this exemption must receive training on the requirements and condition of this exemption in addition to the training required by §§ 172.700 through 172.704.

No person may use or apply this exemption, including display of its number, when the exemption has expired or is otherwise no longer in effect.

12. REPORTING REQUIREMENTS: The carrier is required to report any incident involving loss of packaging contents or packaging failure to the Associate Administrator for Hazardous Materials Safety (AAHMS) as soon as practicable. (Sections 171.15 and 171.16 apply to any activity undertaken under the authority of this exemption.) In addition, the holder(s) of this exemption must inform the AAHMS, in writing, of any incidents involving the package and shipments made under the terms of this exemption.

Issued in Washington, D.C.:

AUG 15 2003

Robert A. McGuire (DATE)
for Associate Administrator for
Hazardous Materials Safety

Address all inquiries to: Associate Administrator for Hazardous Materials Safety, Research and Special Programs Administration, Department of Transportation, Washington, D.C. 20590. Attention: DHM-31.

Copies of this exemption may be obtained by accessing the Hazardous Materials Safety Homepage at http://hazmat.dot.gov/exemptions Photo reproductions and legible reductions of this exemption are permitted. Any alteration of this exemption is prohibited.

PO: Schoonover/sln

Appendix 1: Example DOT Exemption DOT-E 12039 (cont'd)

Continuation of DOT-E 12039 (4th Rev.) APPENDIX A Page 4

AUG 15 2003

The following are hereby granted party status to this exemption based on their application(s) submitted in accordance with § 107.107 or § 107.109, as appropriate.

Company Name City/State	Application Date	Issue Date	Expiration Date
Lyondell Chemical Company Houston, TX	Dec 28, 2001	Jan 18, 2002	Nov 30, 2003
Equistar Chemicals, LP Houston, TX	Dec 28, 2001	Jan 18, 2002	Nov 30, 2003

Robert A. McGuire
For Associate Administrator for
Hazardous Materials Safety

Appendix 2: Example Cargo Tank Inspection Checklist

(Courtesy of a member company of the Cryogenic Ethylene Transportation Safety Panel)

LIQUID ETHYLENE TANK TRUCK

INSPECTION CHECKLIST

GENERAL INFORMATION

CARRIER: _____
DATE: _____
TRAILER BEING: LOADED _____ UNLOADED: _____
TRAILER NUMBER: _____
CORRECTCOMMODITY STENCILED:
"ETHYLENE REFREGERATED LIQUID": YES ___ NO ___
PROPER PLACARD APPLIED:
"FLAMMABEL GAS – 1038": YES ___ NO ___
TANK TEST DATE (LOG ALL DATES):
V (EXTERNAL) _____ I (INTERNAL VISUAL) _____
L (LINING) _____ K (LEAKAGE) _____
P (PRESSURE) _____ T (THICKNESS) _____
RUPTURE DISC TEST DATE _____ DUE DATE: _____
SRV TEST DATE: _____ DUE DATE: _____

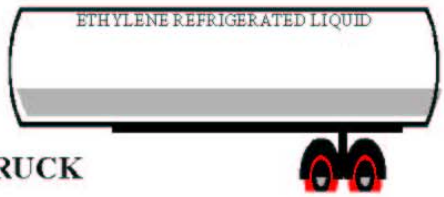
ARRIVAL INSPECTION

BEFORE PROCEEDING, ENSURE THAT BRAKE IS SET, WHEELS ARE CHOCKED, AND GROUND CABLE IS ATTACHED.

FOR ITEMS LISTED BELOW, CHECK "YES" IF ITEM IS IN GOOD CONDITION - CHECK "NO" IF ITEM IS NOT IN GOOD CONDITION. IF ITEM IS CHECKED "NO", WRITE EXPLANATION IN COMMENT SECTION:

YES ___ NO ___ HAS REMOTE SHUTOFF FOR EMERGENCY VALVE
YES ___ NO ___ TANK IS IN GOOG CONDITION (NO MAJOT DENTS, PUNCTURES, CONSIDERABLE RUST, OR EVIDENCE OF LEAKAGE)
YES ___ NO ___ LEVEL AND PRESSURE GAUGES OPERABLE?
YES ___ NO ___ VALVES OPERABLE?
YES ___ NO ___ CORRECT PLACARDS (PROPER UN NUMBER (1038), FOUR TOTAL)
YES ___ NO ___ PLACARD CONDITION (NOT FADED, MISSING, TORN, OR DIRTY)
YES ___ NO ___ DOT CONTAINER NUMBER ON TRAILER
YES ___ NO ___ ALL STENCILING LEGIBLE?

Appendix 2: Example Cargo Tank Pre-trip Inspection Form (cont'd)



LIQUID ETHYLENE TANK TRUCK

INSPECTION CHECKLIST

ARRIVAL PRESSURE: _____

COMMENTS: _____

INSPECTED BY: _____ DATE: _____

DEPARTURE INSPECTION

ARE THE FOLLOWING ITEMS SECURED?

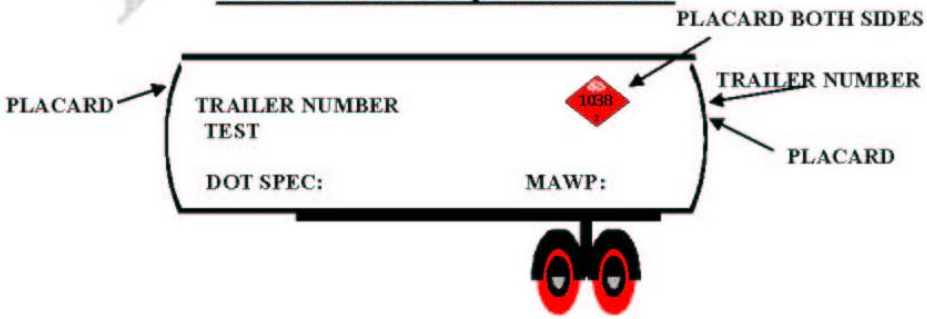
YES ___ NO ___ SAMPLE POINT
YES ___ NO ___ VALVES (CLOSED AND CAPPED)
YES ___ NO ___ DUST COVERS IN PLACE
YES ___ NO ___ LEVEL / PRESSURE GAUGES BLOCKED IN AND BLED DOWN
YES ___ NO ___ DOORS LOCKED AND SEALED

LIQUID (INCHES): _____
PRESSURE: _____
DATE: _____ TIME: _____
SEAL NUMBER(S): _____

COMMENTS: _____

INSPECTED BY: _____ DATE: _____

STENCILING REQUIREMENTS



Appendix 3: Example Trip Pressure Report for Cargo Tanks (Courtesy of Jack B. Kelly, Inc.)

Liquid Ethylene Trip Pressure Report for Cargo Tanks

Driver Name(s) _____ **Home Terminal** _____
Trailer Number: _____ **Trip Number:** _____ **Shipping Order:** _____
Cargo Tank Pressure at Start of this Trip: _____ **Time:** _____ **Date:** _____ **Temperature:** _____

INSTRUCTIONS:

For each shipment, **the driver shall make a written record of the cargo tank pressure and ambient (outside) temperature**:

1. At the start of each trip,
2. Immediately before and after any manual venting (Note: If venting is required, note before and after pressures),
3. At least once every five (5) hours, and
4. At each delivery point **before starting "pressure building" for product delivery** and after delivery and venting is completed.

NOTE: Contact Dispatch immediately if there is an increase in pressure of 5 psi (or more) in a two (2) hour interval.

Submit this FORM with your Shipping Documents.

	Time (use 24-hr time)	Date	Location	Cargo Tank Pressure after 5-hrs driving & no delivery (psi)	Cargo Tank Pressure upon arrival at customer & **before Opening PB Valve** (psi)	Cargo Tank Pressure after blowing down trailer at customer after delivery (psi)	Liquid Level (inches)	Road Relief Valve Setting	OWTT for pressure setting of road relief valve	Air Temp (°F)
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										

__ Check here and add comments on reverse side

Appendix 3: Example Trip Pressure Report for Cargo Tanks (cont'd)

(Reverse Side of Form)

SPECIAL PRECAUTIONS - FLAMMABLE CRYOGENIC LIQUIDS

GENERAL :
Flammable cryogenic liquids are generally extremely cold, highly flammable, and are normally transported at pressures not exceeding 75 psi. Leaks may be readily observed by frosting and vapor clouds from a leak. Care should be taken to remove all sources of ignition. Frosted areas may produce burns if contacted by exposed flesh.

CONTROLLED GAS RELEASE (MANUAL VENTING):
Manual venting is normally not done by the driver. If it is to be done, contact both the shipper and carrier personnel. If the trailer is in an upright position, venting should be done via the vent stack. Precautions should be taken to direct vapor away from sources or ignition (which may include, but not be limited to, open flames, electrical high lines, gasoline engines, radios, static electricity, etc.). Isolate the area a minimum distance of 400 feet. If the trailer is on its side, liquid may be present in the vent stack.

EMERGENCY PROCEDURES:

Should an emergency involving the product arise, isolate the vehicle from populated areas and sources of ignition if possible. Remove shipping papers, contact emergency response personnel (fire and/or local police) and appropriate carrier personnel. Secure the area and await instructions.

TELEPHONE CONTACTS:

24 Hour Emergency Numbers

CHEMTREC - (800) 424-9300

Use this Space for comments and notes:

Appendix 4: Example DOT Exemption DOT-E 11186 for "Isotainer" Operation (From DOT website http://hazmat.dot.gov/exemptions)

U.S. Department
of Transportation
**Research and
Special Programs
Administration**

400 Seventh St., S.W.
Washington, D.C. 20590

AUG 5 2003

DOT-E 11186
(THIRTEENTH REVISION)

EXPIRATION DATE: July 31, 2005

(FOR RENEWAL, SEE 49 CFR § 107.109)

1. GRANTEE: Chart Industries, Inc.
Storage Systems Division
Cleveland, OH

2. PURPOSE AND LIMITATIONS:

a. This exemption authorizes the manufacture, mark, sale and use of a non-DOT specification vacuum insulated portable tank conforming with all regulations applicable to a DOT Specification MC 338 cargo tank motor vehicle for the transportation in commerce of the materials authorized by this exemption. This exemption provides no relief from the Hazardous Materials Regulations (HMR) other than as specifically stated herein.

b. The safety analyses performed in development of this exemption only considered the hazards and risks associated with transportation in commerce.

3. REGULATORY SYSTEM AFFECTED: 49 CFR Parts 106, 107 and 171-180.

4. REGULATIONS FROM WHICH EXEMPTED: 49 CFR § 173.318 in that portable tanks are not authorized; §§ 176.30 and 176.76(g), except as specified herein.

Appendix 4: Example DOT Exemption DOT-E 11186 for "Isotainer" Operation (Cont'd)

Continuation of DOT-E 11186 (13th Rev.) AUG 5 2003 Page 2

5. BASIS: This exemption is based on the application of Chart Industries, Inc. dated July 10, 2003, submitted in accordance with § 107.109.

6. HAZARDOUS MATERIALS (49 CFR § 172.101):

Proper Shipping Name/ Hazardous Material Description	**Hazard Class/ Division**	**Identification Number**	**Packing Group**
Argon, refrigerated liquid *(cryogenic liquid)*	2.2	UN1951	N/A
Carbon Dioxide, refrigerated liquid	2.2	UN2187	N/A
Ethane, refrigerated liquid	2.1	UN1961	N/A
Ethylene, refrigerated liquid *(cryogenic liquid)*	2.1	UN1038	N/A
Helium, refrigerated liquid *(cryogenic liquid)*	2.2	UN1963	N/A
Methane, refrigerated liquid *(cryogenic liquid) or* Natural gas, refrigerated liquid *(cryogenic liquid)*, with high methane content.	2.1	UN1972	N/A
Nitrogen, refrigerated liquid *(cryogenic liquid)*	2.2	UN1977	N/A
Nitrous Oxide, refrigerated liquid	2.2	UN2201	N/A
Oxygen, refrigerated liquid *(cryogenic liquid)*	2.2	UN1073	N/A
Trifluoromethane, refrigerated liquid	2.2	UN3136	N/A

Appendix 4: Example DOT Exemption DOT-E 11186 for "Isotainer" Operation (Cont'd))

Continuation of DOT-E 11186 (13th Rev.) AUG 5 2003 Page 3

7. SAFETY CONTROL MEASURES:

a. PACKAGING - Prescribed packagings are 12 models of non-DOT specification portable tanks designed, constructed and "U" stamped in accordance with Section VIII, Division 1 of the ASME Code. Each tank must conform to the design criteria set forth below:

CRYENCO MODEL NUMBER	WORKING PRESSURE (PSIG)	MINIMUM TEMP. (°F)	VOLUME (GALS)	DRAWING NUMBER
TVS-23-PB-45	45	-320	2300	257794
TVS-33-PB-45	45	-320	3306	254967 or 258778
TVS-22-PB-90	90	-320	2283	253005
TVS-32-PB-90	90	-320	3289	253856-10
TVS-54-PB-60	60	-320	5400	252363
TVS-54-VB-60	60	-320	5400	253191
TVS-53-PB-150	150	-320	5350	118467
TVS-53-VB-150	150	-320	5350	253763
TVS-53-B-150-He	150	-453	5200	252846
TVS-52-PB-250	250	-320	5270	251966
TVN-52-EB-350	350	-320	5200	256468
TVN-520B--350	350	-320	5200	256098

Each portable tank is vacuum insulated and enclosed in a frame that meets all requirements of an ISO standard frame except for overall dimensions. The portable tank must conform to Chart Industries, Inc. (formerly Cryenco, Inc.'s) drawings, calculations and specifications on file with the Office of Hazardous Materials Exemptions and Approvals (OHMEA). Packagings authorized must conform with § 178.338 except as follows:

(1) § 178.338-2(c): Impact testing is not required for stainless steels used for a lading warmer than -425°F.

Appendix 4: Example DOT Exemption DOT-E 11186 for "Isotainer" Operation (Cont'd)

Continuation of DOT-E 11186 (13th Rev.) AUG 5 2003 Page 4

(2) § 178.338-6(b): Each portable tank in oxygen or nitrous oxide service must be provided with an inspection access hole (manhole) of not less than 16.0 inches (406 mm) diameter. After a final inspection the access hole must be closed by welding using a suitable access cover plate fabricated from the same material as the tank. The tank must be provided with a means of entrance and exit through the jacket, or the jacket must be marked to indicate the access hole location.

(3) § 178.338-10: This section does not apply.

(4) § 178.338-13(a): Lifting lugs, framework and any anchoring to the inner tank or the tank jacket must conform with § 178.338-13(a). The portable tank need not conform to § 178.338-13(b) or (c).

(5) § 178.338-18(a)(1): Each portable tank must be plainly and durably marked "DOT-E 11186" in place of the DOT Specification Number MC-338.

(6) A portable tank that meets the definition of "container" must meet the requirements of 49 CFR parts 450 through 453, and each design must be qualified in accordance with § 178.270-13(c).

b. TESTING - The portable tank must be reinspected and retested once every five years in accordance with the procedure prescribed in § 173.32(e) for DOT Specification 51 portable tanks. In place of the requirement for visual inspection, before and after vacuum readings must be used to detect leakage. Nitrogen or an inert gas may be used as a test medium in place of air or water as required by § 173.32(e)(2)(i). The test pressure for the inner tank must be determined from the following formula:

$$P_T = 1.25 \times [P_d] - 14.7$$

Where:

P_T = Test pressure, psig

P_d = Design pressure (the sum of the maximum allowable working pressure, liquid head and 14.7 psi)

Appendix 4: Example DOT Exemption DOT-E 11186 for "Isotainer" Operation (Cont'd)

Continuation of DOT-E 11186 (13th Rev.) AUG 5 2003 Page 5

c. OPERATIONAL CONTROLS -

(1) Each portable tank must be prepared and shipped as required in § 173.318, as applicable for the lading.

(2) No person may transport a portable tank containing Division 2.1 liquid unless the pressure of the lading is equal to or less than that used to determine the marked rated holding time and the OWTT is equal to or greater than the elapsed time between the start and termination of travel.

(3) For the transport of Division 2.1 liquid, the actual holding time for each tank must be determined after each shipment. If it is determined that the actual holding time is less than 90 percent of the MRHT of the tank, the tank may not be refilled until it is restored to its MRHT or the tank is remarked with the reduced holding time determined by this examination.

8. SPECIAL PROVISIONS:

a. In accordance with the provisions of Paragraph (b) of § 173.22a, persons may use the packaging authorized by this exemption for the transportation of the hazardous materials specified in paragraph 6, only in conformance with the terms of this exemption.

b. A person who is not a holder of this exemption, but receives a package covered by this exemption, may reoffer it for transportation provided no modification or change is made to the package or its contents and it is offered for transportation in conformance with this exemption and the HMR.

c. A current copy of this exemption must be maintained at each facility where the package is offered or reoffered for transportation.

d. Each packaging manufactured under the authority of this exemption must be either (1) marked with the name of the manufacturer and location (city and state) of the facility at which it is manufactured or (2) marked with a registration symbol designated by the Office of Hazardous Materials Exemptions and Approvals for a specific manufacturing facility.

Appendix 4: Example DOT Exemption DOT-E 11186 for "Isotainer" Operation (Cont'd)

e. A current copy of this exemption must be maintained at each facility where the package is manufactured under this exemption. It must be made available to a DOT representative upon request.

f. Each portable tank must be plainly marked on both sides near the middle, in letters at least two inches high on a contrasting background, "DOT-E 11186", in place of "MC 338".

g. Transportation of Division 2.1 (flammable gases) materials are not authorized aboard cargo vessel unless specifically authorized in the Hazardous Materials Table (§ 172.101).

9. MODES OF TRANSPORTATION AUTHORIZED: Motor vehicle, rail freight, and cargo vessel.

10. MODAL REQUIREMENTS:

a. A current copy of this exemption must be carried aboard each cargo vessel or motor vehicle used to transport packages covered by this exemption.

b. Shipments by cargo vessel must conform with the following:

(1) The package and its stowage must conform with § 176.76(g). In all situations, the portable tanks must be stowed such that they are readily accessible and can be monitored in accordance with the provisions of this exemption. Portable tanks may be overstowed only if enclosed in ISO frames and the following provisions are met:

(i) The pressure of the lading is equal to or less than that used to determine the marked rated holding time and the OWTT is equal to or greater than the elapsed time between the start and termination of travel.

(ii) The actual holding time for each tank must be determined after each shipment. If it is determined that the actual holding time is less than 90% of the MRHT of the tank, a charged tank may not be overstowed until it is restored to its MRHT or the tank is re-marked with the reduced holding time determined by this exemption.

Appendix 4: Example DOT Exemption DOT-E 11186 for "Isotainer" Operation (Cont'd)

(2) The legend "One-Way Travel Time ___ Hours" must be marked on the shipping paper or on the dangerous cargo manifest immediately after the container description. The OWTT is determined by the formula:

OWTT = MRHT - 24 hours.

(3) A written record of the portable tank's pressure and ambient (outside) temperature at the following times must be prepared for each shipment.

(i) At the start of each trip;

(ii) Immediately before and after any manual venting;

(iii) At least every 24 hours; and

(iv) At the destination point.

(4) Any lading road relief valve set at a pressure lower than that prescribed for the (safety) pressure relief valve must be closed during transportation by cargo vessel.

(5) The requirements of paragraphs, 10.b(2) and (3) above are waived if all of the following conditions are met:

(i) The lading is liquid nitrogen.

(ii) Transportation by cargo vessel is to oil and gas production facilities within the jurisdiction of the United States of America.

(iii) The portable tank is not overstowed with other containers or freight.

c. The portable tank may not be transported in container-on-flat car (COFC) or trailer-on-flat car (TOFC) service except under conditions approved by the Associate Administrator for Safety, Federal Railroad Administration.

11. COMPLIANCE: Failure by a person to comply with any of the following may result in suspension or revocation of this exemption and penalties prescribed by Federal hazardous materials transportation law 49 U.S.C. 5101 et seq:

Appendix 4: Example DOT Exemption DOT-E 11186 for "Isotainer" Operation (Cont'd)

- All terms and conditions prescribed in this exemption and the Hazardous Materials Regulations, 49 CFR Parts 171-180.

- Registration required by § 107.601 et seq., when applicable.

Each "Hazmat employee", as defined in § 171.8 who performs a function subject to this exemption must receive training on the requirements and conditions of this exemption in addition to the training required by § 172.700 through § 172.704.

No person may use or apply this exemption, including display of its number, when the exemption has expired or is otherwise no longer in effect.

12. REPORTING REQUIREMENTS: The carrier is required to report any incident involving loss of packaging contents or packaging failure to the Associate Administrator for Hazardous Materials Safety (AAHMS) as soon as practicable. (Sections 171.15 and 171.16 apply to any activity undertaken under the authority of this exemption.) In addition, the holder(s) of this exemption must also inform the AAHMS, in writing, as soon as practicable of any incidents involving the package and shipments made under this exemption.

Issued in Washington, D.C.

AUG 5 2003

(DATE)

for Robert A. McGuire
Associate Administrator for
Hazardous Materials Safety

Address all inquiries to: Associate Administrator for Hazardous Materials Safety, Research and Special Programs Administration, Department of Transportation, Washington, D.C. 20590. Attention: DHM-31.

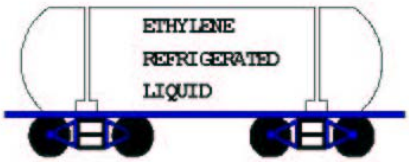
Copies of this exemption may be obtained by accessing the Hazardous Materials Safety Homepage at http://hazmat.dot.gov/exemptions Photo reproductions and legible reductions of this exemption are permitted. Any alteration of this exemption is prohibited.

PO: PTOlson/alb

Appendix 5: Example Tank Car Loading Checklist

(Courtesy of a member company of the Cryogenic Ethylene Transportation Safety Panel)

LIQUID ETHYLENE TANK CAR LOADING CHECKLIST



GENERAL INFORMATION

TANK CAR NUMBER: _____
DATE: _____
CAR RETURNING FROM REPAIR FACILITY: YES____ NO _____
IF "YES," WHY:_____
ARRIVAL PRESSURE _____ (PSIG)
ARRIVAL LIQUID LEVEL: _____ (IN.)
ARRIVAL MICRONS: _____
COMMODITY STENCILED: _____
(4) "FLAMMABLE GAS 1038" PLACARDS APPLIED: YES ____ NO ____
TANK CAR DOT SPECIFICATION NUMBER: _____
RUPTURE DISC TEST DATE: _____ DUE DATE: _____
SAFETY RELIEF TEST DATE: _____ DUE DATE: _____

ARRIVAL INSPECTION

BEFORE PROCEEDING, ENSURE THAT HAND BRAKES ARE SET, WHEELS ARE CHOCKED, DERAIL IS ON, BLUE FLAG IS SET, AND GROUNDING CABLES ARE ATTACHED.

FOR ITEMS LISTED BELOW, CHECK "YES" IF ITEM IS IN GOOD CONDITION - CHECK "NO" IF ITEM IS NOT IN GOOD CONDITION. IF ITEM IS CHECKED "NO", WRITE EXPLANATION IN COMMENT SECTION:

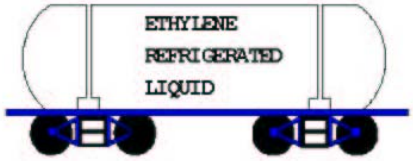
YES ____ NO ____ DEFECT CARD HOLDER EMPTY (NO DEFECT CARD)
YES ____ NO ____ ANY DENTS OR PUNCTURES ON THE TANK JACKET
YES ____ NO ____ ANY SIGNS OF LEAKAGE
YES ____ NO ____ VACUUM PUMP CONNECTION COVER IN PLACE
YES ____ NO ____ SAFETY RELIEF DEVICE IN GOOD CONDITION
YES ____ NO ____ RUPTURE DISCS IN GOOD CONDITION
YES ____ NO ____ LIQUID AND PRESSURE GAUGES IN GOOD CONDITION
YES ____ NO ____ ALL VALVES CLOSED
YES ____ NO ____ THERMOCOUPLE (MICRON HEAD) IN GOOD CONDITION
YES ____ NO ____ GASKETS O.K. FOR UNLOADING

COMMENTS: _____
INSPECTED BY: _____ DATE: _____

PLEASE PROCEED TO NEXT PAGE

Appendix 5: Example Tank Car Loading Checklist (cont'd)

LIQUID ETHYLENE
TANK CAR LOADING
CHECKLIST



SHIPPING INSPECTION

VACUUM (MICRONS): _____ (MAX. 75)
LIQUID (INCHES): _____
PRESSURE: _____(MAX. 10 PSIG)
SEAL NUMBER(S): _____

ARE THE FOLLOWING ITEMS PROPERLY SECURED:
YES ____ NO ____ VALVES CLOSED AND CAPPED
YES ____ NO ____ VALVES SECURED WITH SPRINGS / BUNGEE CORDS
YES ____ NO ____ GAUGE VALVES (BLOCKED/BLED DOWN)
YES ____ NO ____ CABINET DOORS LOCKED AND SEALED
YES ____ NO ____ PLACARDS IN GOOD CONDITION
YES ____ NO ____ GROUND CABLES, CHOCKS, BLUE FLAG, AND DERAIL REMOVED?

COMMENTS: _____
INSPECTED BY: _____ DATE: _____

Appendix 6: Example Tank Car Unloading Checklist

(Courtesy of a member company of the Cryogenic Ethylene Transportation Safety Panel)

LIQUID ETHYLENE TANK CAR UNLOADING CHECKLIST

GENERAL INFORMATION

TANK CAR NUMBER: _____
DATE: _____
ARRIVAL PRESSURE _____ (PSIG)
ARRIVAL LIQUID LEVEL: _____ (IN.)
ARRIVAL MICRONS: _____
COMMODITY STENCILED: _____
(4) "FLAMMABLE GAS 1038" PLACARDS APPLIED: YES ____ NO ____
TANK CAR DOT SPECIFICATION NUMBER: _____
RUPTURE DISC TEST DATE: _____ DUE DATE: _____
SAFETY RELIEF TEST DATE: _____ DUE DATE: _____

ARRIVAL INSPECTION

BEFORE PROCEEDING, ENSURE THAT HAND BRAKES ARE SET, WHEELS ARE CHOCKED, DERAIL IS ON, BLUE FLAG IS SET, AND GROUNDING CABLES ARE ATTACHED.

FOR ITEMS LISTED BELOW, CHECK "YES" IF ITEM IS IN GOOD CONDITION - CHECK "NO" IF ITEM IS NOT IN GOOD CONDITION. IF ITEM IS CHECKED "NO", WRITE EXPLANATION IN COMMENT SECTION:

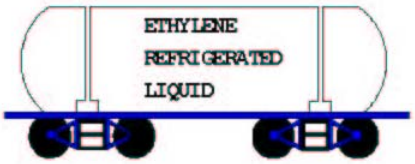
YES ____ NO ____ DEFECT CARD HOLDER EMPTY (NO DEFECT CARD)
YES ____ NO ____ ANY DENTS OR PUNCTURES ON THE TANK JACKET
YES ____ NO ____ ANY SIGNS OF LEAKAGE
YES ____ NO ____ SAFETY RELIEF DEVICE IN GOOD CONDITION
YES ____ NO ____ RUPTURE DISCS IN GOOD CONDITION
YES ____ NO ____ LIQUID AND PRESSURE GAUGES IN GOOD CONDITION
YES ____ NO ____ ALL VALVES CLOSED
YES ____ NO ____ THERMOCOUPLE (MICRON HEAD) IN GOOD CONDITION
YES ____ NO ____ GASKETS O.K. FOR UNLOADING

COMMENTS: _____
INSPECTED BY: _____ DATE: _____

PLEASE PROCEED TO NEXT PAGE

Appendix 6: Example Tank Car Unloading Checklist (cont'd)

LIQUID ETHYLENE
TANK CAR UNLOADING
CHECKLIST



SHIPPING INSPECTION

VACUUM (MICRONS): _____
LIQUID (INCHES): _____
PRESSURE: _____
SEAL NUMBER(S): _____

ARE THE FOLLOWING ITEMS PROPERLY SECURED:
YES ____ NO ____ VALVES CLOSED AND CAPPED
YES ____ NO ____ VALVES SECURED WITH SPRINGS / BUNGEE CORDS
YES ____ NO ____ GAUGE VALVES (BLOCKED/BLED DOWN)
YES ____ NO ____ CABINET DOORS LOCKED AND SEALED
YES ____ NO ____ PLACARDS IN GOOD CONDITION
YES ____ NO ____ GROUND CABLES, CHOCKS, BLUE FLAG, AND DERAIL REMOVED?

COMMENTS: _____
INSPECTED BY: _____ DATE: _____

Appendix 7: Example Isotainer Inspection Checklist (Courtesy of Eastman Chemical Company)

ISOTAINER INSPECTION CHECKLIST

Carrier: _____ Date: _____
Trailer No.: _____ Inspected By: _____
At Tank Truck Spot: _____

BEFORE LOADING	(Initial One) Yes	No	N/A
1. Instructions on Loading Report Read and Followed	___	___	___
2. DOT MC _____ Last Pressure Test Date			
3. Mechanical			
Internal Safety Valve Operative	___	___	___
External Valve Operative	___	___	___
Ladder Secure	___	___	___
4. Cleanliness			
General Appearance Is Clean	___	___	___
Top Unloading Area of Trailer Is Clean (Free of Chemicals and Road Film)	___	___	___
Outlet Caps and Gaskets in Good Condition and in Place	___	___	___
Dome Cover and Gasket – Clean, Good Condition, and Sealing Properly	___	___	___
Outlet Lines Clean and Dry (Inspect With Valve Open)	___	___	___
Compartments Free of Trash, Clean and Dry	___	___	___
Compartments' Odor Acceptable	___	___	___
5. ETHYLENE T/Ts ONLY			
One-Way Travel Time Information on Side of Ethylene Trailer	___	___	___
DOT Exemption Number on Paperwork and Both Sides of Container	___	___	___
6. HOT PRODUCTS ONLY (TMPD, NPG-90, NPG, Acetic Acid)			
Trailer Insulated With Heating Coils	___	___	___
Interior Valves Insulated and Traced	___	___	___
Downlegs Insulated	___	___	___
7. HAc T/Ts ONLY (Check With B-54-5 Control Room)			
Circle Flare That Vapors Are Routed To (3, 3A)			
Flare Pilot Lit?	___	___	___

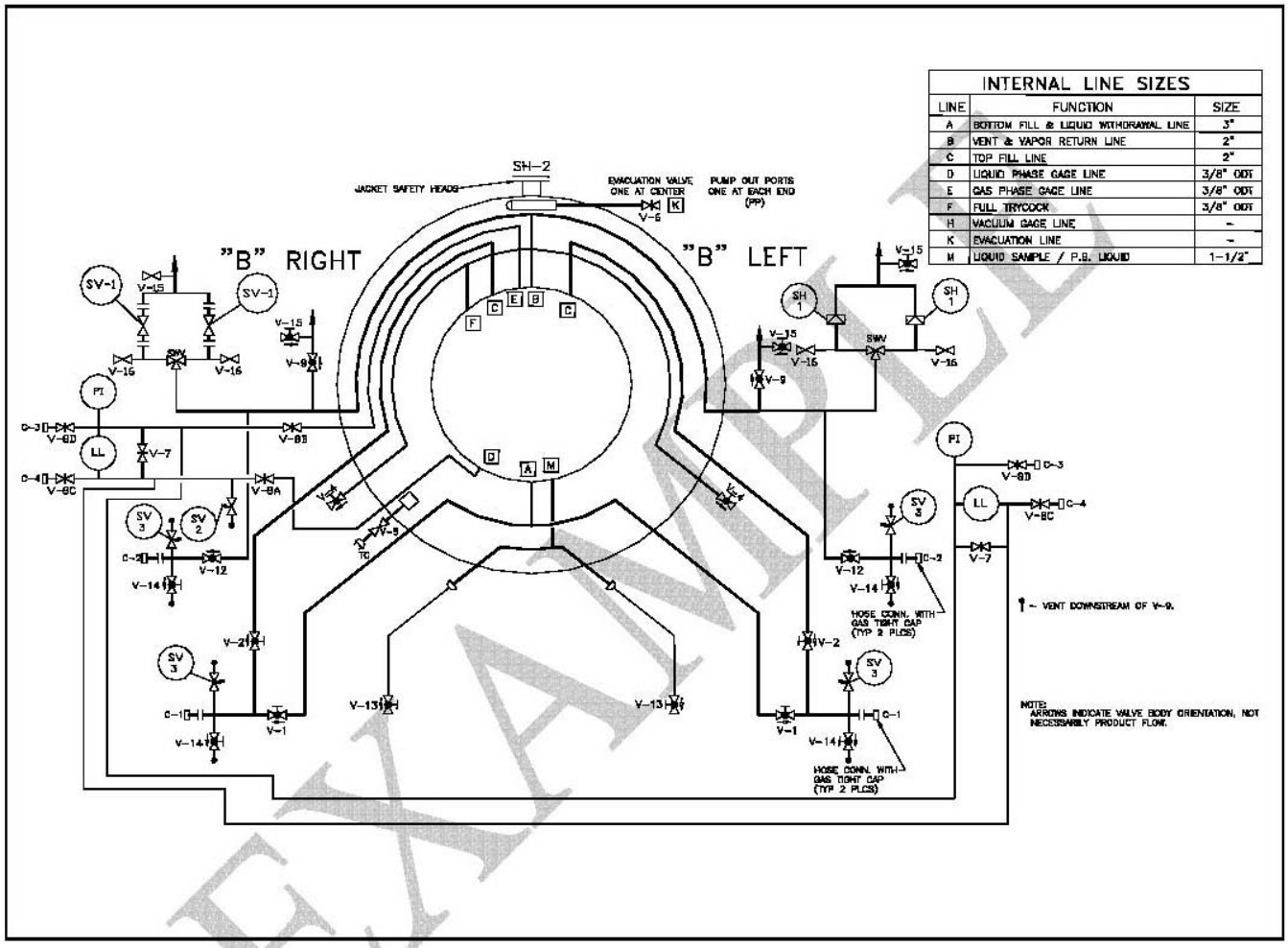
*Personnel inspect only the carrier's trailer as shown above. Carrier has sole responsibility for ensuring tractor pumps and hoses are clean.

WAIVER OF INSPECTION	Yes	No	N/A
Trailer Accepted for Loading	___	___	XXX
Driver's Signature Date			
COMMENTS: _____			

AFTER LOADING	Yes	No	N/A
1. Truck Sampled	___	___	___
2. All Valves Closed, Leak-Free, and Caps in Place	___	___	___
3. Spew Gauges Closed	___	___	___
4. HAc T/Ts ONLY – Flare Pilot Continuously Lit During Loading (See Proc. FS-018)	___	___	XXX

WEAR PERSONAL SAFETY EQUIPMENT WHILE INSPECTING TRAILERS

Appendix 8: Example Diagram of Fittings in Cabinet of Tank Car (Courtesy of Chart Industries, Inc.)



Appendix 9: DEFINITIONS & ACRONYMS

AAR	Association of American Railroads
AAR EAG	Association of American Railroads Emergency Action Guide
ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning
BLEVE	Boiling Liquid Expanding Vapor Explosion
BOE	Bureau of Explosives
Cargo tank	Tank truck designed to carry a liquid or compressed gas by road
CAS	Chemical Abstract Service
COFC	Container-On-Flat-Car
CFR	U.S. Code of Federal Regulations
Cryogenic	A refrigerated liquid having a boiling point colder than –90º C (-130º F) at 101.3 kPa (14.7 psia) absolute
DOT	U.S. Department of Transportation
ERG	2000 DOT Emergency Response Guidebook
Exemption	Document issued by Associate Administrator of RSPA that authorizes deviations from particular Federal Regulations
FRA	Federal Railroad Administration
Frangible disc	Rupture disc, burst disc

Hazmat employee	(49 CFR §171.8) means a person who is employed by a hazmat employer and who in the course of employment directly affects hazardous materials transportation safety. This term includes an owner-operator of a motor vehicle which transports hazardous materials in commerce. This term includes an individual, including a self-employed individual, employed by a hazmat employer who, during the course of employment: (1) Loads, unloads, or handles hazardous materials; (2) Manufactures, tests, reconditions, repairs, modifies, marks, or otherwise represents containers, drums, or packagings as qualified for use in the transportation of hazardous materials; (3) Prepares hazardous materials for transportation; (4) Is responsible for safety of transporting hazardous materials; or (5) Operates a vehicle used to transport hazardous materials. (6) Conforms to the requirements for the construction, testing and marking of large packagings as specified in the UN Recommendations.
IARC	International Agency for Research on Cancer
IMO	International Maritime Organization
Isotainer	International Standards Organization (ISO) container
Micron	A unit of measure for vacuum
Micron Meter	An electronic device that reads the microns of vacuum measured by the thermocouple on a cryogenic tank car
NTP	National Toxicology Program
OSHA	Occupational Safety & Health Administration
Outage/Ullage	Amount by which a packaging falls short of being liquid full, usually expressed in percent by volume.
PRV	Pressure relief valve or safety valve
psig	Pounds per square inch gauge
RCRA	Resource Conservation and Recovery Act
RSPA	Research and Special Programs Administration of the U.S. Department of Transportation
Rupture Disc	The operating part of a non-reclosing pressure relief device designed to burst when subjected to pressure above its rating.

Tank Car	Rail car designed to carry a liquid or compressed gas by rail
Tare Weight	Weight of empty container
Thermocouple	Device that measures microns of vacuum in annular space
TOFC	Trailer-On-Flat-Car
Truck frame	Wheel assembly on a tank car