



SAFETY IN STORAGE, HANDLING AND DISTRIBUTION OF CRYOGENIC ETHYLENE

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Prepared by WG-6 Cryogenic vessels

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Table 1 Properties of ethylene and some comparable substances 4

1 Introduction

Because of the growth in the availability and use of cryogenic ethylene in Europe, the European Industrial Gases Association (EIGA) has recognised the need to publish guidance addressing safety in the storage, handling and distribution of cryogenic ethylene.

This EIGA publication is intended as guidance to companies directly associated with the installation of cryogenic ethylene storage at the user's premises and the distribution of cryogenic ethylene by road, rail and sea transport.

2 Scope

This publication applies to the layout, design and operation of fixed storages and the transportation of cryogenic ethylene in bulk form by tankers or tank containers, by road, sea and rail, to fixed storages at user's premises.

Small transportable cryogenic vessels of less than 1000 litres are excluded from the scope of this publication due to the requirements for a vent system, see 5.7.

3 Definitions

3.1 Publications terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May and Need Not

Indicate that the procedure is optional.

3.1.4 Will

Used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Cryogenic ethylene storage

Storage installation on a user's premises is the installed cryogenic storage tank including heat exchangers and piping up to the battery limit excluding the customer owned piping.

3.2.2 Driver

Generic term used to identify the person(s) who drives the vehicle and is responsible for transferring the product.

3.2.2 Equipment owner

Owner or operator of the equipment, who is responsible for the installation, maintenance and removal of the system.

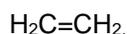
3.2.2 Transferring

Process of unloading product.

4 Properties and effects of ethylene

4.1 General

Cryogenic ethylene has the UN number UN1038. The chemical formula is C₂H₄ and is arranged as:



Cryogenic ethylene is invariably accompanied by a certain amount of gaseous ethylene. For this reason, it is necessary to consider the properties of both liquid and gaseous ethylene. Common properties of ethylene are summarised in Table 1.

4.2 Physical properties

Cryogenic ethylene gas is heavier than air and can accumulate in low areas. Ethylene gas density at normal temperature and pressure is just slightly less than that of air. Due to its similar weight of air in gaseous form, ethylene will not rapidly dissipate and can therefore collect if not allowed sufficient room and air movement.

4.3 Chemical properties

Ethylene is not significantly reactive or corrosive at cryogenic temperatures. At elevated temperatures and pressures, ethylene undergoes violent chemical change, reacts violently with water or can form explosive mixtures with water. Ethylene is extremely flammable and therefore presents a possible explosion hazard.

Ethylene is easily ignited; its minimum ignition energy is very low, 0,07 mJ, *Ignition Handbook, Fire Science* [1]¹. In practice ethylene venting or leaking to atmosphere, particularly from a pressure source can ignite due to electrostatic or self-igniting impurities in the ethylene.

Ethylene burns in air with an orange flame and produces no soot.

The range of flammability of ethylene in air is approximately 3.1% - 32%, *Air Liquide Gas Encyclopaedia* [2]. Confined mixtures of ethylene and air or oxygen can explode very strongly and can detonate.

Ethylene flames, especially those emanating from a high-pressure source, are extremely difficult to extinguish. The best way of extinguishing is to shut off the flow.

4.4 Biological effects

Ethylene is colourless (transparent), with a sweet odour and taste (odour threshold is approximately 270 - 600 ppm, the recognition level is about 418 ppm). Ethylene can act as an asphyxiant by displacing the oxygen in the surrounding air. Moderate concentrations can cause headache, drowsiness, muscular weakness, excitation, excess salivation, vomiting and unconsciousness.

Breathing a pure ethylene atmosphere will produce immediate loss of consciousness and almost immediate death. The amount of ethylene necessary to produce dangerous oxygen deficiency is

¹ References are shown by bracketed numbers and are listed in order of appearance in the reference section.

significantly higher than the lower flammability limit. Therefore, the primary risk of ethylene is not asphyxiation but fire and explosion.

Cryogenic ethylene has specific effects on the human body.

Further information can be found in the safety data sheet for ethylene.

4.5 Specific properties and effects of cryogenic ethylene

Its density is approximately 50% that of water. Cryogenic ethylene is very cold, with a boiling point of minus 103.7°C (169.4 K) at 1 atmosphere.

Cryogenic ethylene, and the cold boil off gas, evolving from the liquid, can produce severe burns (similar to thermal burns) upon contact with skin. Delicate tissue, such as those of the eyes can be injured by exposure to the cold gas or splashed liquid in a brief period, that would normally be too short to affect the skin of the hands or face. Contact between unprotected parts of the body with uninsulated piping or components containing cryogenic ethylene can cause the flesh to stick and tear.

Cryogenic ethylene and cold boil off gas can cause many common materials such as carbon steel, plastic or rubber to become brittle and prone to fracture under stress.

At cryogenic ethylene temperatures, moisture and carbon dioxide can solidify. Such solid particles can plug restricted areas such as valves and orifices. This can lead to a failure of, flow and/or pressure increase. Furthermore, condensed air in cryogenic ethylene is a potential explosion hazard.

Cryogenic ethylene, spilled to the atmosphere evaporates rapidly. One litre of cryogenic ethylene gives approximately 473 litres of gaseous ethylene at ambient conditions.

Cold boil-off ethylene is denser than air and can accumulate in pits and trenches. Cold boil-off ethylene condenses the moisture in the air, thus creating a highly visible fog.

Table 1 Properties of ethylene and some comparable substances
(Values taken from a number of sources)

	Valid at		Ethylene	Methane	Propane	Heptane ²
Boiling point	1.013 bara	K	169.4	111.6	231.1	371.5
Critical temperature		K	282.36	119.6	396.8	540.4
Critical pressure		bara	50.4	46.0	42.4	27.5
Density of liquid	Boiling point	kg/m ³	567.7	422.5	580.7	680 ³
Heat of vaporisation	Boiling point	kJ/kg	482.41	510.4	427.8	317.0
Density of gas	Boiling point	kg/m ³	2.068	1.818	2.419	3.29
Density of gas	1.013 bara 0°C	kg/m ³	1.261	0.717	2.011	4.46
Specific heat, C _p	1.013 bara 0°C	kJ/kg K	1.46	2.19	1.56	1.70 ⁴
Specific heat, C _v	1.013 bara 0°C	kJ/kg K	1.15	1.67	1.35	N/A
Thermal conductivity	1.013 bara 0°C	W/m K	0.0174	0.0305	N/A	0.0188 ⁵
Diffusion coefficient (in air)	1.013 bara 20°C	cm ² /S	0.0944	0.22	0.12	0.05
Limits of flammability ¹	1.013 bara 20°C	Vol.- %	3.1-32	5.0-15.4	2.1-9.5	1.11-6.7
Auto ignition temperature ¹	1.013 bara	°C	450	595	470	215
Minimum ignition energy [1] ¹	1.013 bara 20°C	mJ	0.07	0.28	0.26	0.24
Theoretical temperature of flame ¹	1.013 bara	°C	2343	1875	2040	2200

1. Combustion with air
2. As a representative for gasoline
3. At 0°C
4. Vapour at 25 °C
5. Vapour at 100°C

Conversion: 1bar = 10⁵ Pa

5 Customer installations

5.1 General

Pressure vessels and associated equipment shall be designed, constructed and installed in accordance with appropriate regulations, for Europe this would be the Pressure Equipment Directive [3].

The installation shall be sited to minimise risk to personnel, local population and property. Consideration should be given to the location of any potentially hazardous processes in the vicinity, that could jeopardise the integrity of the storage installation.

5.2 Minimum safety distances

Safety distances shall not be less than applicable national regulations and codes and take into account different basic needs including:

- Ensuring protection to people in the vicinity in case of accidental events;
- Ensuring the integrity of the surrounding technical equipment in case of the same accidental events; and
- Allowing access for emergency services when needed.

The determination of safety distances should be based upon experience and a risk assessment including:

- Properties of liquid ethylene including density, pressure and temperature;
- Design of the pressure vessel and piping configuration;
- Piping and valve sizing commonly used in storage tanks at user's premises;
- Calculation of minor releases from liquid phase piping;
- Weather effects;
- Location and height of vent stack(s);
- Heat flux effects of an ethylene flame; and
- Local overpressure due to flame ignition;

Safety distances shall be measured from:

- Those points, at which in the course of operation an escape of ethylene can occur including vent stacks, filling connections, flanges or mechanical joints; and
- The outer jacket of the vessel.

The safety distances may be reduced if additional protection, is located between the cryogenic ethylene installation and the exposure.

Where protective structures such as fire walls are installed, the following limits apply:

- To minimise the consequence of an accidental leakage, the vessel should not be enveloped or constricted by walls or buildings;
- If the vessel is installed in close proximity to a building or a fire-resistant wall, a minimum distance of 2.5 metres should apply;
- Further walls (for example a vessel in two or three-sided zone) should be avoided as much as possible to prevent accidental gas confinement, if leakage occurs; and
- If proximity to more than one wall cannot be avoided, the above safety distances should be increased, or the wall structure should be strengthened to withstand an increased overpressure.

5.3 Location of installation

All cryogenic ethylene storage installations at user's premises shall be situated in the open air. Cryogenic ethylene installations shall not be located inside buildings. Underground installations should not be considered without exceptional mitigation measures.

The storage tank shall be located so that it is readily accessible to mobile supply equipment at ground level and to authorised personnel. Suitable roadways or other means of access for emergency equipment, such as fire department apparatus, shall be provided.

The slope of the ground shall be such as to provide normal surface water drainage.

Fencing is required to prevent access of unauthorised persons, where other means are not provided. On controlled sites with sufficient supervision, fencing is optional.

Where fencing is provided the minimum clearance between the fence and the installation shall be 0.8m to allow free access to and escape from the enclosure.

Timber or other readily combustible materials shall not be used for fencing. The height of the fencing should be at least 2m.

Adequate means of escape in the case of emergency shall be provided. In cases where personnel could be trapped inside compounds there shall not be less than two separate outward opening exits, remote from each other, strategically placed in relation to the degree of hazard considered.

All gates shall be outward opening and wide enough to provide for an easy access and exit of personnel.

- The main gate should be at least 1.2m wide; and
- The emergency exit gate should be at least 0.8m wide.

Gates shall be locked during normal operation.

Consideration should be given to the provision of an additional emergency exit where the size of fenced area or equipment location necessitates this.

Any firebreak walls or partitions shall be made of brick, concrete or any other suitable non-combustible material of 90 minutes rating.

The installation should be suitably protected from vehicular impact. Barriers or bollards may be used to provide protection from vehicular traffic.

5.4 Liquid transfer area

The liquid transfer area should be designated a "NO PARKING" area.

A road tanker or tank container; when in position for filling from or discharging to the installation shall be in the open and not be in a walled enclosure from which the escape of liquid or cold vapour is restricted. Tankers should have unrestricted access to and exit from the installation at all times.

The fill coupling of the installation shall be located within the tank compound.

5.5 Electrical equipment and installation

The installation and operation of electrical systems in ethylene installations (inside the distance given in Table 2, item 15) shall be in accordance with the national regulations, standards and codes of practice and in particular with the ATEX Directive relating to equipment and protective systems intended for use in potentially explosive atmospheres [3].

Normal electrical installations (not explosion-proof) should be outside the distance given the ATEX assessment zone plan, but not less than 8 metres.

During operation, sparks, electrical arcs, or high temperatures likely to cause ignition shall be precluded within the prescribed safety distances.

Adequate lighting shall be provided for night deliveries as appropriate.

All equipment used and installed within the boundary of the installation shall be in accordance with the requirements of the area classification.

All systems shall be bonded and effectively earthed to give protection against the hazards of electrical currents and static electricity in accordance with national codes/regulations, with a resistance to earth of less than 10 Ohms. To ensure that the requirements for the prevention of the build-up of static electricity on equipment are met, a competent person prior to commissioning shall carry out an inspection.

Major items of equipment such as the tank, vaporizer, piping and vent stack shall be bonded directly to the earth point and not rely upon the piping as a means to earth.

Electrostatic charges can occur when mechanical separation or abrasion of similar or different substances takes place and when a gas, containing droplets or dust particles, flows past the surface of a solid, for example valve openings, hose or pipe connections. If accumulated, electric charges are released suddenly, the resulting electric spark can be sufficiently strong to ignite ethylene. To prevent the accumulation of such charges they shall be allowed to dissipate to earth.

All delivery vehicles shall be earthed prior to commencement of the discharge procedure.

Driving belts and pulleys of pumps shall be of conductive material.

Care shall also be taken in the choice of material for clothing and protective wear since most synthetic materials readily generate static charges.

5.6 Tank foundation and supports

The tank foundation shall be designed to withstand the weight of the tank, its contents and other possible loads applied by wind, snow and seismic.

Where cryogenic ethylene storage tanks are required to be elevated the tank supports shall be non-combustible structures, and capable of withstanding damage by cryogenic liquid spillage.

The foundation on which the equipment is installed shall be made of concrete or any other suitable non-flammable material.

5.7 Ethylene vent stacks

All vents including those of safety relief devices and purge valves shall be connected to a vent stack.

The vent stack shall be arranged to discharge in a safe place in the open air to prevent impingement of escaping gas on to personnel or any structure. The vent stack shall not discharge where accumulation of ethylene can occur, such as below the eaves of buildings.

Consideration shall be given to the prevention of accumulation of water, including that from condensation, in the vent stack outlet. Relief devices shall connect to the vent stack with a downward slope in elevation to prevent water accumulation in the device.

To prevent water being sprayed onto a vent stack, the following signage shall be present on the vent stack; "DO NOT SPRAY WATER ON VENT STACK".

The position of the vent stack(s) shall be taken into account in the siting of the installation and reflected in the areas classification drawing.

The vent stack(s) shall be dedicated to the installation and not connected to other vent stacks that could back feed into the ethylene stack(s).

The height of the vent stack outlet should be either 7 metres above ground level or 3 metres above the top of the tank or structures, whichever is the greater for protection of the operating personnel and equipment.

5.8 Vapour clouds

When siting an installation, consideration shall be given to the possibility of the movement of vapour clouds, originating from spillage or venting; in addition, surrounding equipment, buildings, wind direction (wind vane) and the topography shall be taken into account.

5.9 Piping, fittings, valves, regulators

Piping, fittings, gaskets, thread sealant, valves, regulators and other accessories shall be suitable for liquid or gaseous ethylene service as applicable and for the pressures and temperatures involved. See EN-ISO 21028-1, *Cryogenic vessels -- Toughness requirements for materials at cryogenic temperature -- Part 1: Temperatures below -80 degrees C* and EN ISO 11114 -1 *Gas cylinders -- Compatibility of cylinder and valve materials with gas contents -- Part 1: Metallic materials* and EN ISO 11114 *Gas cylinders -- Compatibility of cylinder and valve materials with gas contents -- Part 2: Non-metallic materials* [5, 6, 7]

Consideration shall be given to the thermal expansion and contraction of piping systems when exposed to temperature fluctuations of ambient to cryogenic temperatures.

Joints in piping and tubing should be welded, brazed, flanged or screwed. Electrical continuity shall be maintained throughout the system.

Means shall be provided to minimise exposure of personnel to piping operating at low temperatures.

Where it is necessary to run gaseous ethylene pipelines in the same duct or trench used for electrical cables, then all joints in the ethylene pipelines in the ducted/trenched section shall be welded or brazed.

Where ammonia or chlorine are likely to be present as an atmospheric contaminant, copper and copper/tin/zinc base alloys shall not be used for pipe or fittings since these materials are susceptible to be attacked by these contaminants. Consideration should also be given to the possibility of other contaminants being present and adequate precautions be taken.

5.10 Back flow

A device, such as a check valve, shall be fitted after the ethylene vaporiser to avoid back flow into the ethylene system.

5.11 Instruments and cabinets

Instruments and gauges shall be designed and located such that, in the event of a leakage or rupture, and possible subsequent fire, the risk to personnel is minimised. The use of safety glass and blow-out backs on pressure gauges is recommended.

Cabinets or housings containing ethylene control equipment shall be designed to prevent any accumulation of ethylene gas.

5.12 Cryogenic ethylene vaporisers

Interconnecting piping shall be sufficiently flexible to provide for the effect of expansion and contraction due to temperature changes.

The vaporiser and its piping shall be protected against over pressurisation with suitable relief devices as required.

The vaporiser shall be adequately sized for the maximum flow requirement specified by the customer.

Where necessary, a device should be installed to ensure that cold gas temperature exiting the vaporiser cannot:

- Cause damage to pipework and equipment downstream; and
- Affect the customer's process.

See EIGA Doc 133 *Cryogenic Vaporisation Systems – Prevention of Brittle Fracture of Equipment and Piping* [7].

5.13 Access to the installation

5.13.1 Personnel

The installation shall be designed that authorised persons shall have easy access to and exit from the operating area of the installation at all times.

Access to the installation shall be forbidden to all unauthorised persons. Warning notices shall support this.

5.13.2 Access to installation controls

Filling connections and equipment controls shall be easily accessible.

Connections and equipment controls necessary for filling purposes shall be located in close proximity to each other and in such a way that tank and tanker controls are visible and easily accessible from the operator's position.

5.14 Notices and instructions

Notices shall be in accordance with local standards and clearly displayed, to be visible at all times, on or near the tank, particularly at access points, to indicate the following:

- CRYOGENIC ETHYLENE
- FLAMMABLE LIQUID / FLAMMABLE GAS
- NO SMOKING
- NO OPEN FLAMES
- AUTHORISED PERSONS ONLY
- DO NOT SPRAY WATER ON VENT STACK

To facilitate control during an emergency, a sign shall be displayed at the installation showing:

- Gas supplier's name and local address;

- Gas supplier's local phone number; and
- The phone number of the local emergency service.

This information shall also be made available at a control point / security office / main gate.

All displayed warning signs and labels shall be in accordance with the relevant national regulations and legible from outside the installation fence.

Operating and emergency instructions shall be supplied to the customer before commissioning the installation.

5.15 Testing and commissioning

5.15.1 Testing of cryogenic storage installation

Prior to commissioning the following tests shall be carried out by the supplier or his representative in accordance with established procedures.

5.15.2 Pressure test / leak test

Where a pneumatic test is specified, dry, oil free nitrogen or other inert gas shall be used. The pressure in the system shall be increased gradually up to the test pressure. Any defects found during the test shall be rectified in an approved manner and the system retested. The testing shall be documented.

Plant instruments including gauges are not normally fitted during any pressure test. They shall be fitted prior to pressurizing for leak testing. (Leak testing consists of checking for leaks at joints and is normally carried out a pressure below that of design pressure).

5.15.3 Purging

Inert gas purge

Following the pressure test and prior to the introduction of ethylene into any part of the system, oxygen shall be eliminated from the system.

This can be achieved by purging, pressurizing and venting with an inert gas, for example nitrogen, and shall be followed by a check to ensure that any residual oxygen is less than 0.5%. Evacuation (vacuum pump) can be used only for piping systems (cryogenic inner vessels should not be subject to vacuum).

Purging procedures shall be prepared for each installation, making individual reference to valves and equipment to ensure that all parts of the system are safe for the introduction of ethylene.

5.16 Pressure relief devices

Pressure relief devices shall be arranged to discharge unobstructed to atmosphere through a vent stack and shall not allow impingement of escaping liquid or gas upon personnel, the tank, or adjacent structures. All vents shall be piped away to the vent stack.

Pressure relief devices or vent piping shall be designed or located so that moisture cannot collect and freeze in a manner that could interfere with the operation of the device.

Pressure relief devices shall be provided to prevent over pressure, including situations where liquid can be trapped.

Pressure relief valve inlet pressure drop shall not exceed 3% without a study by a competent person to ensure the proper operation of the system. Pressure relief valve exit pressure drop shall not exceed 10% under all credible scenarios without an engineered study by a competent person to ensure the proper operation of the system.

If a diverter valve is installed to accommodate two pressure relief devices operating, either simultaneously or alternatively, then the size of the valve, regardless of the position of the actuating device shall be such that the vessel is adequately protected. The diverter valve should be provided with a position indicator, if appropriate, showing which relief devices are on line.

For the capacity of pressure relief devices refer to ISO 21013-3, *Cryogenic vessels -- Pressure-relief accessories for cryogenic service -- Part 3: Sizing and capacity determination* [8]

A secondary relief device such as a bursting disc or redundant relief valve shall be installed together with the primary relief device of the tank.

Consideration shall also be given in the design of the installation to facilitate the periodic testing of the pressure relief devices.

5.17 Commissioning

Commissioning shall only be carried out by the equipment owner or agent, with authorized and trained personnel and in accordance with a written procedure.

5.18 Decommissioning and removal of tank

Decommissioning shall only be carried out by authorized and trained personnel and in accordance with a written procedure. Prior to dismantling the system or removing the tank the entire installation shall be purged into inert gas service (less than 25% of the lower explosive limit).

5.19 Operation of the installation

5.19.1 Operating personnel

Only authorized persons shall be allowed to operate the installation. Operating instructions shall be supplied to the user's personnel; these instructions shall define the safe operating limits. Instructions shall be written and presented in a clear and concise format in the national language(s).

The hand wheels of those valves that are to be shut in an emergency should, for the convenience of the operator, be colour coded or identified by other means.

5.19.2 Operating malfunction or emergency

Any operating malfunction or emergency concerning the installation shall be referred to the ethylene supplier.

The customer shall not modify the supplier's equipment.

Any proposed modification to a customer-owned installation or any attached system should be agreed with the ethylene supplier.

5.20 Periodic inspection and maintenance

5.20.1 Site

The equipment owner shall inspect the site on an annual basis, to ensure that it is maintained in a proper condition and that safety distances are respected.

5.20.2 Tank

Operation of the tank shall be in accordance with EIGA Doc. 114 *Operation of Static Cryogenic Vessels*. *Periodic inspections* shall be in accordance with EIGA Doc. 119 *Periodic Inspection of Static Cryogenic Vessels* [9,10].

The periodic inspection or testing of the inner vessel is not considered necessary and should be avoided if permitted by national regulations. There are sound technical reasons for not exposing the inner vessel to ambient air or to the risk of contamination. For a tank with indications of loss of vacuum see EIGA Technical Bulletin TB 11 *Recommendations for the Prevention of Brittle Failure of the Outer Jacket of Vacuum Insulated Cryogenic Storage Tanks* [11].

5.20.3 Installation

Periodic and planned maintenance of the installed equipment shall be carried out by the equipment owner.

An annual external visual examination should be carried out to confirm the satisfactory condition of the outer vessel, exposed pipe work and controls. A check on the vacuum shall be made if an abnormal pressure increase occurs.

5.20.4 Vaporizers

In cold weather, the operator should regularly check ambient air vaporizers for excessive ice formation that can be removed using steam or hot water.

When a water bath or steam heated vaporizer is used, the operator should carry out regular visual examination of shell and external tube surfaces for signs of damage, excessive frosting etc. Any defects should be reported to the supplier.

5.20.5 Pressure relief devices

Regular visual inspections of the devices shall be carried out during normal operation by the equipment owner.

A regular test of each relief valve shall be carried out to demonstrate its fitness for a further period of service. Pressure relief valves shall be tested or changed out in accordance with EIGA Doc 24, *Vacuum insulated cryogenic storage tank systems pressure protection devices* [12], unless unusual conditions of service dictate more stringent requirements.

Bursting disc elements can deteriorate due to aggressive environments resulting in their relief pressure rating being reduced. It could be necessary to replace disc elements in such environments on a more frequent basis.

5.20.6 Ancillary Equipment

Ancillary equipment other than previously detailed for example pressure/temperature gauges should be maintained in accordance with either manufacturers' recommendations or national codes, whichever is the more stringent.

5.21 Customer information

The information or handover package that shall be given to the customer shall include the following:

5.21.1 Safety data sheets – SDS

The safety data sheet for cryogenic ethylene shall be given to the customer.

5.22 Emergency action procedure

The installation's emergency isolation system shall be situated such that the system can be activated from a safe location and shall be clearly identified.

The system shall be tested on a periodic basis to ensure operability.

6 Transport and distribution of cryogenic ethylene

All these activities shall be in accordance with the applicable national and international regulations.

6.1 Road transport - General

This section covers all operations involved from the time the vehicle leaves the filling plant until it has completed all deliveries given in the route plan and preceded to its final destination.

These operations include:

- route planning;
- periodic checking of the transport;
- parking of tanker or tank container;
- breakdown;
- product transfer into customer storage;
- emergency procedures; and
- driver training.

6.2 Vehicle equipment and design considerations

Consideration should be given to the following when designing a tanker or tank container for use in cryogenic ethylene service.

6.2.1 General design

Electrical equipment, including transfer pump motor and lighting of compartments shall be suitable for ethylene service, for example explosion proof or purged with an inert gas. This does not apply to the automotive electrics.

All enclosures on the tanker or tank container shall be suitably ventilated either by design or operation.

All control equipment shall be adequately protected to minimise the effect of impact damage.

The liquid discharge line shall be equipped with two valves in series, one of which shall be an automatic shut off (fail close).

Care shall be taken to protect equipment not designed for low temperature such as carbon steel, for example vehicle chassis or rubber, plastics, electrical cabling, from piping containing cryogenic ethylene.

The tanker or tank container shall be equipped with an emergency shut off valve that can be activated from both sides of the vehicle.

6.2.2 Warning notices and placards

The product in the tanker or tank container shall be identified according to the requirements of the European Agreement on the Carriage of Dangerous Goods by Road, ADR [13] and/or the appropriate regulations.

All valves and equipment shall be individually tagged according to an instrumentation diagram (P&ID), that is permanently located on the vehicle.

6.2.3 Anti tow away devices

Each vehicle shall be equipped with an anti-tow away device, see EIGA Doc 63, *Prevention of tow away incidents*, [14].

6.2.4 Hose coupling adapters

The use of adapters should be avoided.

If adapters are used to change between two different connection standards or sizes, only one adapter shall be permitted. The issue and use of adapters shall be controlled by a management system.

6.2.5 Safety circuits

The inner vessel shall be protected against overpressure by a dual safety relief device system.

All piping circuits where liquid could be trapped shall be equipped with a relieving device of adequate size and pressure rating.

Piping from all vents and relief valves shall be routed into vent stack(s). The vent stack shall exit through a high point on the cryogenic compartment.

All vehicles shall be equipped with fire extinguisher(s) in accordance with the requirements of ADR, [12].

6.3 Routing, periodic checking, parking and breakdown

6.3.1 Routing

The route planning shall be established before any trip is started indicating the roads the tanker or tank container should take. When deciding the route, the following information should be considered:

Vehicles should be routed to customer premises on primary routes, that is, motorways and main roads, wherever possible.

Densely populated areas should be avoided wherever possible, for example city centres, built-up areas.

The rate of pressure increase within the tanker or tank container should be considered when route planning to ensure that venting of product on the public highway does not occur as this is not permitted by transport regulations.

Vehicles shall not be routed through tunnels unless the tunnel specifically permits dangerous goods.

Drivers shall keep to approved designated routes. If they are diverted from the route, for example by police or roadworks, then, unless the vehicle returns to the original route within a short period, the driver should notify his home base as soon as it is safe to do so.

NOTE Venting of the tanker or tank container is not permitted on the public highway.

6.3.2 Periodic Checking

These checks are in addition to the legal requirements to be performed by the driver.

The vehicle shall undergo a full pre-departure check and a trip report shall be prepared, unless one has been prepared, for example, tank container by sea.

The vehicle should be checked periodically throughout the duration of the trip, including routine checking of the inner vessel pressure.

If abnormal operating conditions are detected the driver should inform their management as soon as possible.

6.3.3 Parking

When parking for meal breaks etc., the vehicle shall be parked in accordance with national legislation, and ADR [13], and wherever possible use should be made of goods vehicle public parking areas, for example, motorway parking areas and always in the open air. If the vehicle is parked for longer periods it should be supervised.

The driver should remain in close proximity to the vehicle.

Parking adjacent to obvious potential hazards shall be avoided, for example beneath overhead power lines, re-fuelling areas, LPG or liquid oxygen tankers.

Parking within 15m of occupied premises or a place where members of the public gather should be avoided.

Vehicles shall not be parked within close proximity to bridges, tunnels or underpasses.

6.3.4 Breakdown

In the event of a breakdown on a public highway, other road users should be warned using hazard warning flashers, reflective triangles and flashing amber lights, as required.

Under no circumstances shall a cryogenic ethylene tanker or tank container in service enter enclosed premises for repair unless the premises are specifically built for ethylene service.

Under no circumstances shall hot work be carried out on a cryogenic ethylene tanker or tank container unless purged with an inert gas, fully authorised and a permit to work issued.

If the trailer is not purged, the tractor shall remain attached to the vehicle unless the tractor or tanker is damaged by fire, or for a tractor change. This is to be able to remove the tanker from a potential dangerous situation.

7 Product transfer into customer storage

Only authorised, trained and certified personnel shall undertake a transfer operation. This includes knowledge of written instructions detailing the product transfer operation.

A transfill operation shall not be undertaken during a thunderstorm and shall be stopped if a storm is imminent.

The risk of overpressure during a fill shall be in accordance with EIGA Doc 151 *Prevention of excessive pressure during filling of cryogenic vessels* [15].

7.1 Before transferring

Upon arrival at the customer premises the driver shall:

- Report to the designated customer personnel before any operation is carried out (if required by the customer);
- Ensure that the delivery vehicle is grounded (electrically connected to earth) before any other operation is carried out and wheel blocks should be used;
- Visually inspect the hose(s) and couplings to establish the mechanical integrity and ensure that the end fittings are undamaged and not dirty;

- Check the surrounding area to ensure that no safety hazards have been introduced; and
- Ensure that prior to liquid transfer the hose(s) are purged prior to delivery.

7.2 Product transfer

Any defect observed by the driver during the transfer operation shall be reported.

Driver(s) shall be in attendance near the operating controls of the tanker or tank container and storage tank during the complete transfer operation.

During transfer, the driver(s) shall wear protective clothing including gloves, eye and face protection, helmet, overalls and protective footwear.

Upon completion of product transfer the delivery hose(s) shall be emptied of liquid ethylene before disconnection.

7.3 Emergency procedure during transport

The vehicle shall clearly display an emergency telephone number, that can be used by the emergency services, public or driver for specialist advice.

Where there is a need to vent excessive tanker or tank container pressure, reference to the route plan shall be made.

If it is not possible to vent at those areas designated within the route plan (due to rapid pressure increase) park the tanker or tank container in the safest possible place taking into consideration the prevailing wind direction and strength.

All incidents shall be reported in writing.

7.4 Driver training

All drivers shall be trained and certified in all aspects related to the distribution and product transfer of cryogenic ethylene. This includes:

- Physical and chemical properties of ethylene, liquid and gas;
- The general design of equipment, including for example, leak tightness, insulation and grounding;
- Tanker and tank container functioning, principle of liquid transfer and different transfer modes;
- Actions to be taken at customer premises;
- Security, driving regulations, dangerous goods transport regulations, instructions for liquid transfer, instructions for cryogenic ethylene handling;
- Instructions in case of accident/breakdown on the road; and
- Reporting requirements.

7.5 Tank container - Transport by rail

The carriage of tank containers by rail shall be in accordance with the Regulations concerning the International Carriage by Rail of Dangerous Goods, RID, [16]. Tank containers offered for rail transport shall have the appropriate approval. The national railway authority can impose additional requirements and these should be requested prior to the journey arrangements being made.

The tank container inner vessel pressure condition shall be suitable for the expected journey time plus 24 hours. A checklist shall be completed to indicate departure condition and a copy carried with the tank container.

A planned route should be agreed with the national railway authority and where the route crosses a border the journey plan shall be supplied to appropriate persons of other national railway authorities together with other relevant information.

A system shall be agreed whereby any deviation from the specified route plan is notified to all persons concerned.

Segregation from other containers and railway wagons will be under the control of the national railway authority. However, the operator shall inform the authority of the dangers that could arise so that the tank container can be positioned away from flammable and oxidising substances, being carried on the same train or on other trains parked in marshalling yards.

Prior to the journey, an emergency telephone system should be set up along the planned journey route with a list of specific contacts, that is, national railway authority, gas company, emergency services.

A document detailing the initial response to an emergency should be provided to the national railway authority and all other appropriate persons along the planned journey route, for example, the emergency services.

The operator (gas company or contractor) should set up an emergency response team(s) to deal with incidents.

Due to the nature of railway activity it may not be possible to measure inner vessel pressure rise at regular intervals. This requirement should be discussed with the individual national railway authority and suitable agreements made, see also EIGA Doc 184, *Methods to prevent the premature activation of relief devices on transport tanks* [17].

A full check of the tank container should be made at the conclusion of the journey. This should be recorded on the checklist. If a further journey by another mode is necessary, the appropriate instructions for that mode shall be followed.

7.6 Transportation by waterways and sea

The requirements for waterways and sea transport are covered in the International Maritime Dangerous Goods Code [18] and general guidelines given in EIGA Doc 41 *Guidelines for transport by sea of multiple element gas containers (MEGCs) and portable tanks for gases* [19], that should also be applied, to road tankers.

It is recommended that a check list be supplied to the shipping line to ensure that performance monitoring of the tanker/tank container is recorded at regular intervals.

Specific instructions should be provided that detail procedures to be followed in the event of an emergency. This is in addition to the requirements of IMDG emergency procedures for ships carrying dangerous goods.

8 Training and protection of personnel

8.1 Training of personnel (gas supplier and customer)

All personnel directly involved in the commissioning, operation and maintenance of cryogenic ethylene storage systems shall be informed regarding the hazards associated with ethylene and trained as applicable to operate or maintain the equipment.

Training shall be arranged to cover those aspects and potential hazards that the operator is likely to encounter.

Training shall cover, but not necessarily be confined to the following subjects for all personnel:

- Properties of liquid and gaseous;
- Properties of liquid and gaseous nitrogen (or other purging gas);
- Potential hazards of ethylene;
- Site safety regulations;
- Emergency procedures;
- Use of firefighting equipment and gas analysers (explosive meter) as applicable;
- Use of protective clothing/apparatus including breathing sets where applicable; and
- First aid treatment for cryogenic burns.

In addition, individuals shall receive specific training in the activities for which they are employed.

It is recommended that the training be carried out under a formalised system and that records be kept of the training given and where possible, some indication of the results obtained, to show where further training is required.

The training programme should make provision for refresher courses on a periodic basis, or in the event of new site personnel.

It is the responsibility of the customers to train their own personnel in accordance with applicable legislation.

8.2 Permit to work

Before maintenance is carried out on the installation, a written permit to work, for example, cold work, hot work and electrical work, shall be issued by an authorised person to the individual(s) carrying out the work, see EIGA Doc 40, *Work permit systems*, [20].

9 Emergency procedures at customer premises

Emergency procedures shall be prepared to cover fire or any other hazardous event that could occur.

The following are guidelines that may be used for formulating emergency procedures:

- Raise the alarm;
- Summon help and emergency service;
- Isolate the source of ethylene, if appropriate and safe to do so;
- Evacuate all persons from the danger area and seal it off;
- Alert the public to possible dangers from vapour clouds and evacuate when necessary; and
- Notify immediately the gas supplier.

9.1 Fire protection

Emergency procedures shall be established for each installation in consultation with local authorities and periodic drills should be carried out.

Water shall be available to keep the equipment cool in the event of fire. The preferred method to extinguish an ethylene fire is to isolate the source of the product.

When water is used to keep equipment cool careful control shall be exercised. Water should not be sprayed near relief valve vents or vent stack outlets due to the potential danger of plugging vents with ice.

9.2 Firefighting equipment

The location and quantity of firefighting equipment shall be determined by risk assessment, depending on the size of the ethylene installation and in consultation with the local authorities/customers.

10 References

Unless otherwise specified the latest edition shall apply.

- [1] Ignition Handbook, V. Babrauskak, Fire Science Publishers,
- [2] Air Liquide Gas Encyclopaedia, <https://encyclopedia.airliquide.com/>
- [3] Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment, www.eur-lex.europa.eu
- [4] Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast) Text with EEA relevance www.eur-lex.europa.eu
- [5] EN-ISO 21028-1, Cryogenic vessels -- Toughness requirements for materials at cryogenic temperature -- Part 1: Temperatures below -80 degrees C, www.cen.eu
- [6] EN ISO 11114 -1 Gas cylinders -- Compatibility of cylinder and valve materials with gas contents -- Part 1: Metallic materials, www.cen.eu
- [7] EN ISO 11114 Gas cylinders -- Compatibility of cylinder and valve materials with gas contents - - Part 2: Non-metallic materials, www.cen.eu
- [8] EIGA Doc 133 Cryogenic vaporisation systems – Prevention of brittle fracture of equipment and piping, www.eiga.eu
- [9] ISO 21013-3, Cryogenic vessels -- Pressure-relief accessories for cryogenic service -- Part 3: Sizing and capacity determination, www.iso.org
- [10] EIGA Doc. 114 Operation of static cryogenic vessels. Periodic inspections, www.eiga.eu
- [11] EIGA Doc. 119 Periodic inspection of static cryogenic vessels www.eiga.eu
- [12] EIGA Technical Bulletin TB 11 Recommendations for the prevention of brittle failure of the outer jacket of vacuum insulated cryogenic storage tanks www.eiga.eu
- [13] EIGA Doc 24, Vacuum insulated cryogenic storage tank systems pressure protection devices, www.eiga.eu
- [14] European Agreement on the Carriage of Dangerous Goods by Road, (ADR) www.unece.org.
- [15] EIGA Doc 63, Prevention of tow away incidents, www.eiga.eu

- [16] EIGA Doc 151 *Prevention of excessive pressure during filling of cryogenic vessels*, www.eiga.eu
- [17] *Regulations concerning the International Carriage by Rail of Dangerous Goods, (RID)* www.otif.org
- [18]. EIGA Doc 184, *Methods to prevent the premature activation of relief devices on transport tanks*, www.eiga.eu
- [19] *International Maritime Dangerous Goods Code*, www.imo.org
- [20] EIGA Doc 41 *Guidelines for transport by sea of multiple element gas containers (MEGCs) and portable tanks for gases*, www.eiga.eu
- [21] EIGA Doc 40, *Work permit systems*, www.eiga.eu