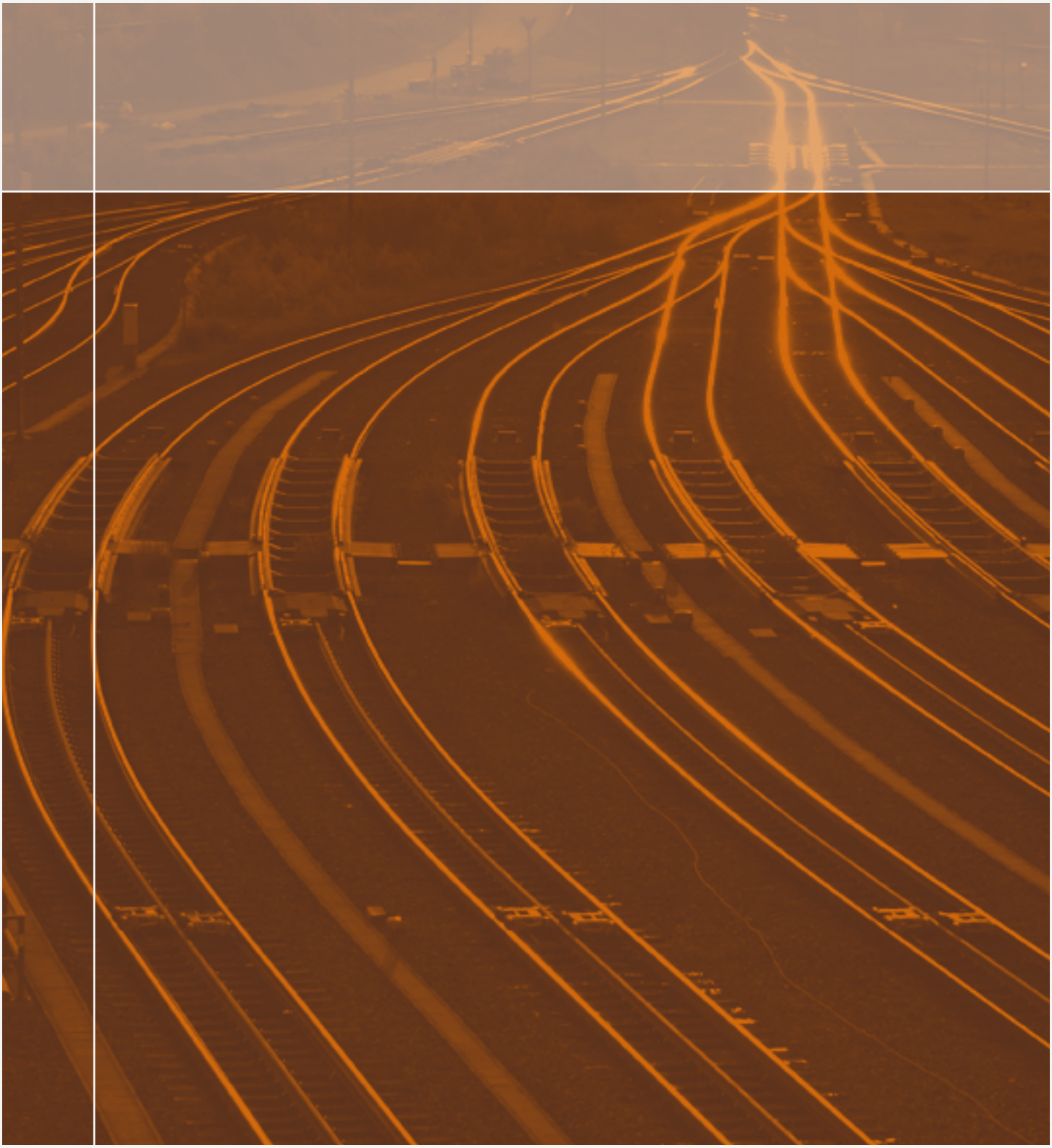
Guidelines for the distribution of

Ethylene Oxide

Fourth Revision - 2013

Ethylene Oxide and Derivatives CEFIC Sector Group



Summary

Summary 2
1 Introduction 3
2 Properties and hazards of ethylene oxide 4
3 Design and construction of transport equipment 9
4 Product training for road tanker and tank container drivers 10
5 Personal safety equipment 11
6 Loading operations 12
7 Transport of ethylene oxide by road 13
8 Transport of ethylene oxide by rail 14
9 Transport of ethylene oxide by sea 15
10 Unloading operations 16
11 A mutual aid scheme for providing assistance at transport emergencies 17

Appendices

Appendix 1 CEFIC and Responsible Care 18
Appendix 2 CEFIC recommendations on safe management practices in distribution (SQAS) 20
Appendix 3 Design and construction of rail tank wagons (RTCs) 21
Appendix 4 Design and construction of road tankers and tank containers 26
Appendix 5 General instructions for ethylene oxide drivers 30
Appendix 6 Inspection of transport equipment 43
Appendix 7 Example of a checklist for Rail Tank Cars 46
Appendix 8 A safety visit scheme for the reception and storage facilities at ethylene oxide customers 49
Appendix 9 Assessment of ferry operators and associated terminal facilities 56
Appendix 10 Sector Group Member companies 58

1 Introduction

1.1

Although ethylene oxide is a hazardous material in terms of flammability, reactivity and toxicity, it can be distributed and handled safely provided that appropriate precautions are observed.

1.2

The transport of ethylene oxide in bulk is subject to strict regulations within most countries in Europe. In addition, the international movement of ethylene oxide by road, rail or sea is subject to international agreements which lay down specific requirements concerning transport which must be observed by all parties involved.

1.3

These Guidelines have been prepared by the CEFIC (European Chemical Industry Council) Ethylene Oxide and Derivatives Sector Group to establish appropriately high standards of Safety for the transport of ethylene oxide.

1.4

These Guidelines take into account the transport of ethylene oxide in bulk in road tankers, rail tank wagons and tank containers. They cover all aspects of the transport activity from loading to delivery point. Reference to existing regulatory controls is only made where this is considered necessary for the purpose of clarification.

1.5

The CEFIC Ethylene Oxide and Derivatives Sector Group recommends that these Guidelines are adopted by all parties who are involved in the distribution of ethylene oxide, and will arrange a regular review of these guidelines.

1.6

In order to facilitate effective supervision of safety in transport to destination, it is recommended that ethylene oxide producers should arrange transport themselves.

1.7

The Guidelines do not deal with the bulk movement of ethylene oxide in gas carrier ships.

1.8

The Cefic (European Chemical Industry Council) Responsible Care Program requires that Chemical Companies demonstrate their commitment to continuously improve all aspects of Performance which relate to Protection of Health, Safety and the Environment. An overview of the Key Elements of Cefic's Distribution Responsible Care Program is contained in appendix 1.

2 Properties and hazards of ethylene oxide

2.1 General data

CAS NUMBER: 75-21-8

UN NUMBER: 1040

SYNONYMS:
- 1,2-Epoxyethane
- Ethene Oxide
- Oxirane

FORM: Gas

WARNING PROPERTIES
The odour of this material is inadequate to warn of excessive exposure.

2.2 Properties

Boiling point at atmospheric pressure	10.5°C (range 10.4° - 10.7°C)
Melting point	- 111.3°C
Flash point (closed cup)	< -18°C
Density (liquid) at 0°C	890 kg/m3
Vapour density (air = 1)	1.52
Heat of evaporation	578 kJ/kg at atmospheric pressure and 10.5 °C
Specific heat - liquid	1.97 kJ/kg °C at 11°C 2.00 kJ/kg °C at 20°C
Specific heat - gas	1.06 kJ/kg°C at 25°C
Heat of polymerisation	2093 kJ/kg
Heat of decomposition of gas	83,700 kJ/kg mole
Heat of combustion	27649 kJ/kg
Electrical conductivity of pure liquid	4 10-6 S/m
Minimum ignition energy at 1 bar and 25°C in air	0.06 mJ
Melting point of hydrate	11°C (maximum at 30 % EO)
Auto ignition temperature	429 °C (as given in text below)
Auto decomposition temperature	560 °C
Smell of pure EO	Not apparent until concentration reaches approx. 500-700 ppm Adaptation may take place. (see also 2.6.1)

2.3 Flammability

Ethylene oxide is highly flammable and has a flash point below -18°C. It is flammable in air at all concentrations above 2.6 % (by volume). There is no upper flammable limit as normally conceived in that exothermic decomposition replaces combustion at the higher ranges up to 100 % ethylene oxide vapour.

Due to its low boiling point and flammability, ethylene oxide is, in some respects, similar to LPG. However, an essential difference is that ethylene oxide is fully miscible with water. Another important difference is that ethylene oxide has an unusually low minimum ignition energy for mixtures in air. The lowest value at about 10.4 % ethylene oxide by volume is 0.06mJ and this figure is similar to the ignition energy of about 0.02mJ required by hydrogen/air mixtures.

Any leaks of ethylene oxide, for example from flanges, must therefore be avoided because of the high risk of ignition. Appearance of frost can be observed in case of liquid EO leaking.

The auto-ignition temperature (AIT) of ethylene oxide in air at atmospheric pressure is 429°C. However, any contaminants present, such as rust can significantly reduce the AIT.

Solutions of ethylene oxide in water may give rise to flammable vapour. Even a 1 % solution of ethylene oxide in water has a closed cup flashpoint of 22°C. As much water as possible should always be used for dilution. If insufficiently diluted solutions enter sewers there may still be a flammability risk.

If ethylene oxide comes into contact with certain insulation materials it can self heat. Temperatures up to 700°C have been recorded. Insulation fires can raise vessel wall temperatures above the auto decomposition temperature and cause explosive decompositions (see section 2.4).

2.4 Chemical reactivity

Ethylene oxide is a highly reactive chemical which reacts exothermically, especially in the presence of a catalyst, with impurities/compounds such as water, alcohols, ammonia, amines, acids/bases and rust. These reactions can be self-accelerating and strongly exothermic, even with only traces of the compound present.

2.5 Decomposition

Pure ethylene oxide vapour decomposes explosively if ignited even in the absence of air. Ethylene oxide decomposition is initiated if the chemical is heated to about 560°C, the auto-decomposition temperature (ADT).

Decomposition is catalysed by metal acetyl ides as well as the metals copper, silver, mercury, and their alloys. Increasing pressure lowers the ADT. The presence of rust may also initiate decomposition at a lower temperature due to the formation of a hot spot caused by polymerisation.

2.6 Polymerisation

Ethylene oxide is stable at room temperature in the absence of catalysts/contaminants. Purely thermal initiation of polymerisation begins at around 100°C.

Polymerisation of ethylene oxide is highly exothermic and, if the temperature is not controlled by removal of heat at a sufficient rate, the polymerisation is self-accelerating. This can lead to vaporisation of unreacted ethylene oxide and also possibly to explosive decomposition of the vapour. This polymerisation can be promoted by impurities or contamination which act as catalysts, for example by acids, bases, metal oxides and anhydrous chlorides of iron, aluminium and tin.

Therefore it is most important to maintain clean equipment when handling ethylene oxide, and to ensure inadvertent mixing with other chemicals does not occur.

Rust is also a moderate initiator of the polymerisation reaction of ethylene oxide. It must be thoroughly removed from any equipment containing ethylene oxide.

At ambient temperature, the polymerisation of ethylene oxide in the presence of rust is slow. The polymer is a thermally stable viscous liquid which is soluble in the monomer. If exposed to water at temperatures higher than 50°C the polymer will react to produce polyethylene glycol which is sticky and difficult to remove from equipment.

2.7 Health hazards

Since ethylene oxide boils at 10.5°C it vaporises rapidly at ambient temperatures and atmospheric pressure.

2.7.1 Acute Toxicity

Acute toxicity data by inhalation route indicates that Ethylene Oxide is hazardous. A study for the inhalation route performed in rats concluded an LC50 of 3.8 mg/l for males and 3.0 mg/l for females (Snellings et al., 2011). Thus, Ethylene Oxide is classified as acutely toxic via inhalation, Cat 3. Acute toxicity data by oral and dermal routes are not applicable as the test substance is a gas on normal conditions (classified toxic by inhalation) and no acute dermal toxicity data are available respectively. However, in vitro studies (Wester et al., 1997 and Von Baumbach et al., 1987) have indicated that Ethylene Oxide can be absorbed via the skin. Under normal operating conditions, this dermal uptake is negligable, due to stringent exposure controls in place. In case of an accidental spill, high concentrations of Ethylene Oxide and subsequent exposure may occur. During clean-up, personnel are often well protected against exposure to Ethylene Oxide via the inhalatory route. It is also crucial to avoid dermal exposure in such cases.

2.7.2 Aspiration Hazard

Ethylene Oxide is not known to be an aspiration hazard based on expert judgment of several physicochemical properties of Ethylene Oxide. Its viscosity is low (0.254 mPa.s at 10 °C); however, high water solubility and no reported cases in humans support that Ethylene Oxide is not an aspiration hazard.

2.7.3 Irritation / Corrosion

Ethylene Oxide was tested in rabbit skin in vivo where it was found to be both irritating and corrosive. Hyperemia and oedema resulted when the duration of skin contact was greater than 6 minutes. It can also lead to scar formation and serious burns. Ethylene Oxide was also tested in rabbit eyes in vivo. Again, it was found to be irritating with the maximum non-damaging concentration of 0.1% ethylene oxide. Based on these findings, Ethylene Oxide is classified as an eye and skin irritant.

2.7.4 Sensitisation

There is no valid animal study data or reliable human study data available for sensitisation in skin or respiratory tract. Since it rapidly evaporates from the skin, ethylene oxide would not be expected to be a skin sensitiser.

2.7.5 Repeated Dose Toxicity

Several long-term inhalation studies have been conducted with Ethylene Oxide in mice, rats, and monkeys. Results demonstrate that repeated exposure to Ethylene Oxide via inhalation results in breathing difficulty and may cause damage to the central and peripheral nervous system. A NOAEC of 10 ppm was identified for both male and female mice and rats. Ethylene Oxide may cause damage to blood-forming organs after repeated ingestion. Ethylene Oxide induced dose-dependent local tumours, mainly squamous-cell carcinomas of the forestomach in female rats (Dunkelberg, 1982). There is no animal data available following dermal exposure; however, aqueous solutions of Ethylene Oxide have caused extensive skin burns with blister formation in a number of human exposure cases.

2.7.6 Mutagenicity - Genetic Toxicity

The genotoxicity of Ethylene Oxide has been tested in both in vitro and in vivo assays. Ethylene Oxide is a genotoxicant. The in vitro gene mutation assays in bacteria (Ames test), rodent fibroblasts, and human lymphocytes have all given positive results for mutagenicity. An in vivo test in rats exposed to a concentration of 1000 ppm of Ethylene Oxide also gave a positive result for mutagenicity. However, when rats were exposed to lower concentrations of Ethylene Oxide, the results were inconclusive. An ambiguous result was also observed when monkeys were exposed to Ethylene Oxide (50-100 ppm) via inhalation. In conclusion, Ethylene Oxide is classified as a category 1B mutagen and as such, may cause heritable genetic damage.

2.7.7 Carcinogenicity

Ethylene Oxide is a rodent carcinogen. Several in vivo studies in rats and mice have been positive for carcinogenicity. A vapour concentration of Ethylene Oxide of ≥33 ppm for 2 years resulted in the occurrence of brain tumours in rats. A NOAEC for carcinogenicity of 10 ppm was identified for both male and female rats. Also peritoneal mesothelioma at a male rat-specific site and leukemias of a Fischer rat-specific site (spleen mononuclear cell leukemia) were observed at increased rates but considered to be of low relevance to man. Lung tumours were increased when mice of both sexes were exposed to a vapour concentration of ≥50 ppm for 2 years. The human relevance of these tumours is unclear since epidemiological studies have failed to demonstrate an association between Ethylene Oxide exposure and lung tumours in humans. Additionally, for workers with very high Ethylene Oxide exposures [combination of exposure levels and years worked], there was an indication of an elevated risk for blood cancers among men and breast cancers among women. Conclusively, ethylene oxide was classified as a category 1B carcinogen.

2.7.8 Toxicity to reproduction - fertility

Based on the results of a one-generation reproductive toxicity study where male and female rats were given vapour concentrations of Ethylene Oxide of 10, 33 and 100 ppm (= about 0.018, 0.054 and 0.18 ml/l) for 6 hours per day and 5 days per week for 12 weeks, a NOAEC of 0.054 ml/l for both the parental animals and F1 generation was identified. No treatment-related effects were observed. Based on these results, Ethylene Oxide is not classified for reproductive toxicity (fertility).

2.7.9 Toxicity to reproduction - development

Based on the results of a developmental study in which rats were given vapour concentrations of Ethylene Oxide of 10, 33 and 100 ppm (= about 0.018, 0.054 and 0.18 ml/l) from gestation day 6 - 15 for 6 hours per day, a NOAEC was identified to be 0.18 ml/l (highest concentration tested) for both maternal toxicity and teratogenicity. In another developmental study in rabbits NOAECs for maternal toxicity and teratogenicity of 0.27 mg/l were identified. There was no evidence of maternal toxicity, adverse effects on development, or structural malformations. Therefore, Ethylene Oxide is not classified for reproductive toxicity (development).

2.8 Environmental hazards

2.8.1 Acute (short-term) aquatic toxicity

The acute aquatic toxicity of Ethylene Oxide has been assessed at two different trophic levels: fish and invertebrates. Fish were the most sensitive trophic level tested with a 96h LC50 of 84 mg/L; daphnia were somewhat less sensitive with a 48h LC50 of between 137-300 mg/L. No acute toxicity studies were carried out on aquatic algae, however, the toxicity of Propylene Oxide and Ethylene Oxide are similar for fish and daphnia, therefore, it can be assumed that the algal toxicity is also comparable. The EC50 (96h) for Propylene Oxide on the growth rate of the green alga Selenastrum capricornutum was measured to be 240 mg/L. Based on these data Ethylene Oxide may potentially be acutely harmful to aquatic organisms.

2.8.2 Chronic (long-term) aquatic toxicity

There are no studies available which assess the chronic aquatic toxicity of Ethylene Oxide.

2.8.3 Environmental fate

Ethylene Oxide achieved 96% degradation (TOC removal) after 28 days during an OECD 301C test as well as 69% degradation after 20 days in an OECD 301D equivalent test. Ethylene Oxide is therefore considered readily biodegradable. The calculated log Kow value of Ethylene Oxide is low (-0.3) suggesting a low tendency to partition to organic phases and therefore a low potential for bioaccumulation in aquatic organisms.

3 Design and construction of transport equipment

3.1 Design and construction of rail tank cars (RTCs)

Rail tank cars for the carriage of ethylene oxide must meet the design and construction requirements of:

a) National Regulations or Local Railway Administration Regulations, when used for national transport, and
b) International Regulations, such as the International Regulations concerning the Carriage of Dangerous Goods by Rail (RID), when used for international transport.

In addition, rail tank cars must be designed and constructed in accordance with the guidelines contained in Appendix 3 or to an equivalent standard.

3.2 Design and construction of road tankers

Road tankers used for the carriage of ethylene oxide by road must meet the design and construction requirements of:

a) National Regulations, when used for national transport, and
b) International Regulations, such as the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), when used for international transport.

In addition to the above requirements, road tankers must be designed and constructed in accordance with the guidelines contained in Appendix 4 or to an equivalent standard.

3.3 Design and construction of tank containers

Tank containers may be used for the carriage of ethylene oxide by road, rail or sea. They must meet the design and construction requirements of the appropriate National or International Regulations depending upon the specific transport modes which are to be utilised.

In addition to the above requirements, tank containers must be designed and constructed in accordance with the guidelines contained in Appendix 4 or to an equivalent standard.

4 Product training for road tanker and tank container drivers

4.1

The ADR agreement requires that all drivers of road tankers or transport units carrying tank containers with a total capacity of more than 3000 litres must have successfully participated in a training course on the particular requirements that have to be met during the carriage of dangerous goods. A similar training requirement for drivers is included in most national transport regulations.

4.2

However, the hazards associated with ethylene oxide are such that drivers should be specifically trained to understand the particular nature of the dangers which may arise during transportation of this product and the actions to be taken in an emergency situation. This training should include security aspects in line with ADR Chapter 1.10.
The content of the specific training which needs to be given is shown in Appendix 5.

4.3

Before a driver is allowed to convey ethylene oxide, he / she:

a) Must have received product training to the standard required by the ADR agreement; and
b) must have successfully participated in a specific training course for ethylene oxide.

4.4

All consignors of ethylene oxide should undertake the responsibility for ensuring that specific product training for ethylene oxide is provided to drivers. Upon successful completion of training and validation, drivers should be provided with a certificate, valid for two years. Drivers should be issued with a copy of the training material in their native language for their retention.

Companies that receive ethylene oxide should be encouraged to ask to see the drivers ethylene oxide training certificate.

5 Personal safety equipment

5.1

In all situations where exposure to ethylene oxide liquid and/or vapour is possible, adequate personal protection should be worn. As a minimum, the following should be used:

a) Eye protection: use chemical resistance safety goggles.
b) Gloves suitable for ethylene oxide
c) Suitable respiratory protective device (Compressed air/Oxygen apparatus or AX-filter)

Protective suits and boots may also need to be considered depending upon the circumstances.
Review your supplier eSDS for more information.

Clothing for spill and fire:

- wear full protective clothing EO resistant gloves under gauntlet type Butyl rubber gloves/
- safety boots and approved positive pressure breathing apparatus
- remove contaminated clothing immediately, preferably under safety shower / fire hose spray
- destroy contaminated clothes, shoes and leather items

5.2

It should be noted that many materials in common use are permeable to or are attacked by ethylene oxide.

Butyl rubber has been found to give the best degree of protection. Neoprene or natural rubber may also be considered for protective clothing, but may not remain vapour-tight after prolonged use.
Leather is permeated by liquid ethylene oxide and PVC and nitrile rubber offer only very limited resistance. Consequently, these materials should not be used for protection against ethylene oxide liquid or vapour. Leather, PVC or nitrile rubber footwear should be avoided. Delayed skin burns may result if ethylene oxide is allowed to permeate through these materials.
Prior to the acquisition of the personal protective equipment (PPE), formal confirmation needs to be obtained from the PPE-manufacturer that the PPE is resistant for EO-use (including breakthrough / degradation time).Following contact with EO-liquid/vapours all used gloves must be discarded.

5.3

If any leather wear does come into contact with ethylene oxide, it should be discarded immediately because decontamination of leatherwear is not possible.

5.4

Eyewash facilities and safety showers (frost-protected as necessary) should be provided in all areas where ethylene oxide is handled.

6 Loading operations

6.1

The operation of filling any road tanker, tank container or rail tank car (RTC) with a dangerous substance is a potential hazard. It is therefore important that loading facilities and transport equipment are correctly designed and constructed, and properly used and maintained.

6.2

The design and construction of transport equipment is described in Chapter 3 of these Guidelines. Equipment, which meets the requirements of the ADR, RID and / or IMO Regulations, is subject to periodic inspection and testing requirements as laid down in these Regulations. The competent authorities carry out official inspection and testing.

6.3

Written operating instructions should be available covering all activities for loading of ethylene oxide into road tankers, tank containers and rail tank cars. Personnel involved should be fully trained in their implementation (involvement of fire brigades in the training is recommended). The instructions should recognise the specific hazards of ethylene oxide, and ensure the correct operation of loading equipment in both normal and emergency situations.

6.4

All necessary protective clothing and emergency equipment should be available for loading operations (see Chapter 5). Personnel should be trained in the correct use of this clothing and equipment.

6.5

It is not the intention of this section of the Guidelines to attempt to set detailed operating instructions for loading ethylene oxide vehicles, since these of necessity will depend upon local operating conditions. However, as part of the operating instructions, the loading terminal staff should carry out an inspection of the transport equipment before, during and after loading. This inspection does not replace or diminish the responsibility of the owner of the road tanker, tank container or rail tank car to ensure that the equipment is properly tested, maintained and fit for purpose. It is meant to ensure that the transport of ethylene oxide is conducted as safely as possible. An inspection list such as the one described in Appendix 4 is recommended for use by the loader to check the condition of the ethylene oxide transport equipment, and this should be applied for all loading operations.

6.6

In addition to the routine inspection of all transport equipment prior to each loading operation, a responsible person from the loading company should carry out a check on each road tanker, tank container or rail tank car prior to initial introduction into service, or reintroduction to service after maintenance or repair. An example of these checks is shown in Appendix 6.

7 Transport of ethylene oxide by road

7.1

The haulier is responsible for the safe transport of ethylene oxide by road from the loading point to the discharge point. Road carriers must meet all relevant national and international regulations related to Ethylene Oxide. Road carriers should participate in an SQAS scheme (Appendix 2). CEFIC guidelines provide a framework for the implementation of the principles of Behaviour Based Safety (BBS) (http://www.cefic.org/en/transport-and-logistics-best-practices-guidelines.html) to safe driving of road freight vehicles. BBS is a programme aimed at increasing safety during transport by positively influencing the behaviour of drivers through observation, coaching and communication. Special consideration should be given to the following:

7.1.1 Routing

The transport of ethylene oxide has to follow the ADR-regulations. According to this the route must be selected carefully. As far as possible, the route should:

a) Utilise motorways,
b) Avoid inhabited areas

7.1.2 Safe parking

Drivers must ensure that the vehicle is either supervised or is parked in a secure place.
No potential source of heat or fire must exist in the vicinity, and the vehicle must be capable of being easily removed in an emergency.
Drivers must inform the haulier of their overnight parking location. The overnight parking locations must be selected in accordance with regulations (for example ADR).

7.1.3 Severe weather conditions

When severe weather conditions are experienced during transport, for example icy roads, snow or poor visibility, the delivery should be stopped at the next suitable parking place.

7.1.4 Delays or accidents

All delays during transport, whether due to severe weather conditions, breakdown or other reasons must be reported to the consignor as soon as possible.
Transport accidents must also be reported to the consignor as soon as possible.

7.1.5 Pressure and temperature checks

For road transport the pressure and/or temperature of the tank contents should be checked every 4 hours and recorded on a checklist or in a logbook.

7.1.6 Emergency procedure

If emergency action needs to be taken by drivers when leaks, spills or fire occur during transport, then the instructions given in the “Instructions in writing” must be followed. They are available in various languages at the following web site: http://www.unece.org/trans/danger/publi/adr/adr_linguistic_e.html

8 Transport of ethylene oxide by rail

8.1

The railway operating companies are responsible for the safe transport of ethylene oxide by rail from despatch siding to final reception siding. The selection of route, intermediate stopping locations and cessation of traffic due to severe weather conditions are matters to be decided by the railway authorities.

8.2

The railway authorities or railway operating companies will normally intervene in the event of a transport emergency involving ethylene oxide rail tank cars. Railway authorities should be made aware of the information contained in these Guidelines as an aid for railway hazardous cargo intervention teams.

8.3

Rail tank cars shall not be transported over the public road from the final rail siding to the customer by a 'piggyback' arrangement. Multimode transport by tank container may provide a viable alternative.

9 Transport of ethylene oxide by sea

9.1

Transport of ethylene oxide by sea may be either:

a) by roll on / roll off freight ferries, or
b) lift on / lift off shipment in tank containers.

Basic requirements for ferry movements are given in the IMDG Code. Local agreements applicable in some sea areas may modify the requirements of the Code in certain circumstances, eg the Baltic Memorandum of Understanding.

Any movement of ethylene oxide must comply with the relevant regulations. In addition, freight only ferries will be used whenever possible. These services may carry road haulage drivers as well as their cargo. If there is no exclusive freight ferry available, then an alternative ferry service may be used, provided that it has been audited, and shown to offer the same degree of safety.

9.2

Because of the nature of the activity, a number of different parties may be involved in the operation of transporting ethylene oxide from consignor to customer. These may include the shipping company, port or harbour authorities and hauliers.

9.3

Prior to the commencement of each traffic flow, the consignor should carry out a safety assessment of each aspect of the transport operation. This assessment should include, as appropriate:

a) the shipping company,
b) loading/unloading facilities at container terminals,
c) emergency handling within hazardous cargo yards at container terminals,
d) emergency handling on board,
e) responsibility for emergency response should be agreed between consignor and customer.

A recommended check list for assessing ferry operators and associated terminal facilities is shown in Appendix 9.

9.4

The consignor may decide to issue specific instructions for the control of the operation to all parties involved and the actions to be taken in the event of an emergency.

9.5

Road tanker or tank container movements involving short sea crossings should be driver accompanied.

10 Unloading operations

10.1

The operation of unloading any road tanker, tank container or rail tank car of ethylene oxide is a potential hazard. It is therefore important that unloading facilities are correctly designed and constructed with respect to the potential hazards and properly used and maintained.

For loading and unloading operations EO selectively coded dry disconnect couplings (NATO standard 3756) are the European standard (liquid: 3 inch selectivity code 3-4; gas: 2 inch selectivity code V; Gasket: Chemraz 505).

10.2

The equipment should be subject to regular checks according to maintenance and inspection standards.

10.3

Written operating instructions should be available for unloading ethylene oxide from road tankers, tank containers and rail tank cars. Personnel involved should be fully trained in their implementation (involvement of fire brigades in the training is recommended). The instructions should recognise the specific hazards of ethylene oxide, and ensure the correct operation of unloading equipment in both normal and emergency situations.

10.4

All necessary protective clothing and emergency equipment should be available for unloading operations (see Chapter 6). Personnel should be trained in the correct use of this clothing and equipment.

10.5

The conditions for discharge of ethylene oxide at a customer's premises are the customer's responsibility. If a customer requires, the consignor may provide him with technical advisory and safety service, which in principle may include safety visits. If a safety visit is made, the scheme included in Appendix 8 may be used. Normally the customer himself should evaluate whether his premises, especially his reception and storage facilities, correspond with the requirements of the scheme included in Appendix 8.

10.6

Appropriate systems should be in place to ensure the identification of the supplied product.

11 A mutual aid scheme for providing assistance at transport emergencies

11.1

All chemical companies involved in the transport of ethylene oxide in Europe should have a system for receiving transport emergency messages and for providing expert advice to minimise any hazard arising from an incident on road, rail or water.

11.2

However, because Europe occupies a very large geographical area, the ability of an individual chemical company to provide expert advice quickly at the scene of an incident may be severely restricted if a considerable distance has to be travelled to reach the scene.

11.3

With the objective of ensuring that expert assistance is available as promptly as possible at the scene of any ethylene oxide transport emergency, all producers participate in a mutual aid scheme for emergency response.

11.4

The principles of the scheme are as follows:

a) If the Emergency Authorities in any country call for assistance from a Company under the provisions of a national scheme, then the provisions of that scheme will be paramount.
b) The Company which has supplied the ethylene oxide (the Supplying Company) must accept the general obligation to respond to the emergency.
c) A second Company (the Assisting Company) may be requested by the Supplying Company to respond, so as to provide:
   - a quicker response, if the Assisting Company is closer to the scene of the incident,
   - equipment
   - reinforcements.
d) The Supplying Company remains responsible when an Assisting Company has been requested to participate.
e) The Assisting Company acts on behalf of the Supplying Company until the latter's representatives reach the scene.
f) All Companies participating in these arrangements make available such services and assistance as would be provided for their own ethylene oxide.

11.5

Regular technical communication has been established between participating Companies in order to:

a) maintain a Mutual Aid procedure based on the principles described in Section 11.4 above,
b) ensure that the training and equipment at participating centres is adequate,
c) agree common methods of approach in the resolution of transport emergency situations.

Appendix 1 CEFIC and Responsible Care

1. Responsible Care - a public commitment

"Chemical companies shall demonstrate their commitment to continuously improve all aspects of performance which relate to protection of health, safety and the environment."

2. Prevention of accidents

Within Responsible Care, prevention is a prerequisite to Emergency Response. The CEFIC-ICE (International Chemical Environment) prevention program provides a valuable tool in reducing the number of incidents during the distribution of chemicals, from the time they leave the factory gate until their arrival at the customer's premises.

3.

The objective is to minimize the possibility for incidents to happen. Since most distribution activities are subcontracted and since compliance with regulations is a necessary but not a sufficient condition to prevent accidents, there is a need for uniform safety & quality criteria against which distribution companies are regularly assessed. Unlike ISO 9002, which concentrates on quality, at a level set by the individual distribution company, SQAS - Safety & Quality Assessment Systems - provide objective performance indicators, which allow the monitoring of continuous improvements.

4.

Based on detailed questionnaires, distribution contractors can be assessed by a qualified third party. Questions relate to management, equipment and operations, split by: statutory requirements, additional chemical industry requirements and desirable items. Scoring results can be presented in different ways but it is up to each individual chemical company to evaluate the results according to its own standards.

The distribution contractors will include:

- Marine transport: Vessels and barges. (Ferries)
- Road transport: Road carriers
- Storage operations: Terminals/Warehouses
- Ferry operators

5. Emergency response

Although the chemical industry has a fine record in preventing chemical transport incidents, it is committed to continuous improvement. The ICE Emergency Response scheme, a cooperative program coordinated by CEFIC, will provide emergency response across national boundaries. It aims to build upon the best existing prevention practices, preserve proven emergency response schemes and extend the best emergency schemes to countries where none exist.

The chemical industry makes its expertise available to authorities - who are normally in charge of the emergency - at three levels of assistance.

Level 1: Remote information and general advice by telephone or fax.
Level 2: Presence of an expert who will provide advice at the scene of an incident
Level 3: Actual help with equipment and personnel at the scene of an incident

For detailed information on this subject consult: the CEFIC ICE - European Emergency Response Network: Operational National ICE schemes (www.cefic.org)

Appendix 2 CEFIC recommendations on safe management practices in distribution (SQAS)

These recommendations conform to the principles of Responsible Care and include the following topics.

1. Safety, health and environmental policies
2. Auditing
3. Risk reduction
4. Specification of packages, tanks and other equipment
5. Incidents evaluation
6. Codes and regulations
7. Control operations
8. Training
9. Selection and monitoring of Contractors
10. Data and information
11. Emergency Response
12. Information to the public

Although these Guidelines for the distribution of Ethylene Oxide are product specific, it is essential that policies, systems and procedures as described in the CEFIC recommendations on Safe Management Practices in Distribution are in place and well maintained.

Appendix 3 Design and construction of rail tank wagons (RTCs)

1. Scope

1.1

Tanks for the carriage of ethylene oxide shall meet the International Regulations concerning the carriage of Dangerous Goods by rail (RID) for this specific product.
The requirements that follow, give supplementary information and do not replace RID requirements, they will apply for all new build rail tank cars and form a guidance for evaluation of rented rail tank cars. Existing rail cars may not be fully in compliance with the following constructions recommendations.

2. Materials of construction

2.1

For new rail tank cars the tank shall be constructed of stainless steel meeting at least the following specification: AISI/SAE 304LN or the according equivalent for the approved Pressure Vessel Code. All materials shall be furnished with a minimum 3.1B certificate according to EN 10204.

2.2

Tank fittings, instrumentation and attachments in contact with ethylene oxide shall also be of the above-mentioned materials, and may not contain copper or alloys of copper and/or magnesium.

3. Tank construction

3.1

Tanks are to be designed according to an approved Pressure Vessel Code (for example ASME BPVC, AD-Merkblätter).

3.2

The Inner side of the tank must be pickled and passivated.
Grinding is only allowed at the bottom part of the tank to allow for complete emptying of the rail tank car.

3.3

Requirements for all pressure retaining welds are:

- Shall be 100 % radiographed.
- All Welding Procedure Specifications (WPS) and Procedure Qualification Records (PQR) must be made available for approval.
- All WPS and PQR must confirm with the approved Pressure Vessel Code.

3.4

No baffle plates are to be fitted

3.5
Reinforcement (backing) plates are required when the load bearing attachments (T-bar, anchor plates..) are not made of a stainless steel (see also "Material of construction").

3.6
The design of the rail tank car must guarantee a complete unloading of the rail tank car (e.g. by means of a slope towards the bottom centre.) Criterion: less than 5 litters of remaining product.

3.7
Nozzles on the shell should, as much as possible, be located away from the shell main weld seams.

3.8
For inspection purposes, the tank shall be fitted with one manhole not less than 500 mm diameter; the manhole shall be fully bolted and may have a hinged design (right hand side).

3.9
All gaskets (between flanges as well as the manhole) must be high purity compressed graphite laminated to tang stainless steel called grooved graphite OR camprofile gasket OR round spiral wound stainless steel type 304, filled with pure graphite (99,9 %). Depending on the flange design inner- and/or outer guide rings are required. (e.g. gaskets for tongue and groove flanges don't have guide rings).

3.10
Valves packing must be resistant to ethylene oxide and all valves must be of a fire-safe design.

3.11
Tanks must be designed so that there are no pockets that can trap liquid during discharge.

3.12
The two screw threaded inlet points at each end of the tank, top centre (to permit the initial pressure test of the tank), shall be seal welded.

3.13
The only openings allowed in the tank are:
- One manhole;
- Two foot valves;
- Two threaded inlet points.

3.14
The welds at the outer side of the shell shall be pickled and passivated.

3.15
In order to protect welds for stress corrosion cracking, all stainless steel surfaces can be coated.

4. Equipment

4.1

Pressure relief devices.
No pressure relief devices shall be fitted.

4.2

Filling/Discharge and Vapour Return fittings:

4.2.1

The tank must be fitted with an NB 80 mm filling/discharge pipe with an 80 mm shut off valve. The vapour return connections shall be a NB 50 mm pipe, fitted with a NB 50 mm shut off valve. Valves shall be of an approved make & type, e.g. bellow valve.

4.2.2

In addition, a quick closing internal safety device shall be fitted in the tank shell for the liquid filling/discharge connection. The device shall be capable of being operated remotely. The device shall also close automatically in the event of a hose rupture or the inadvertent movement of the rail tank car. The valve actuator shall consist of a hydraulic system.

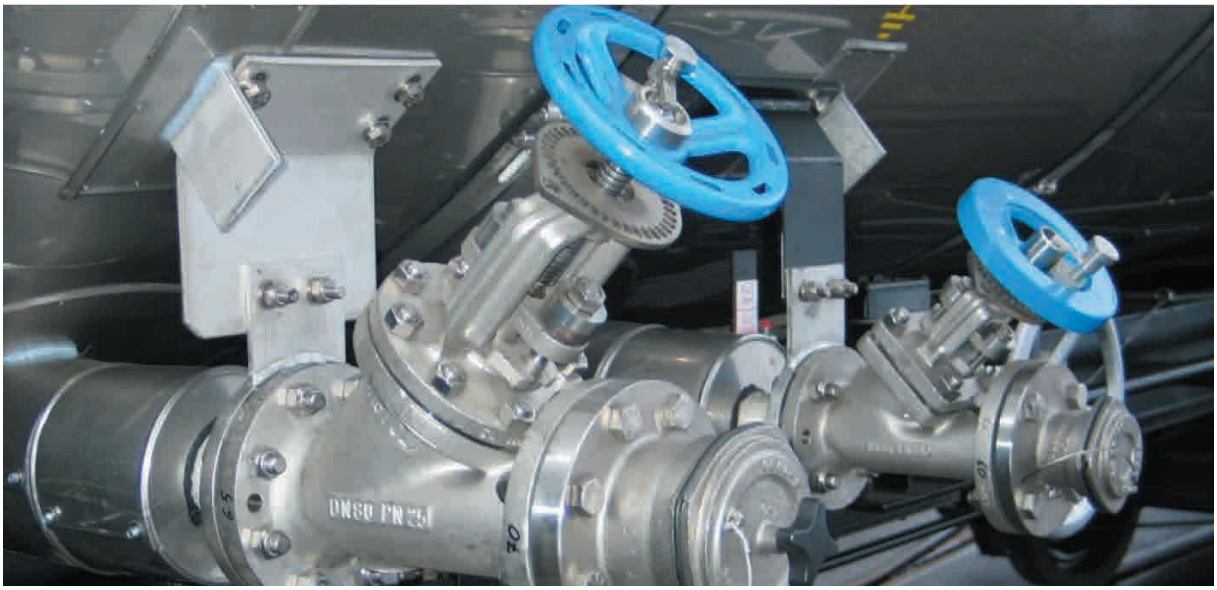
4.2.3

Both the filling/discharge and vapour return connections must be able to be closed by means of a blind flange. Materials of connections must be similar to that of the tank shell.

4.2.4

Both the filling/discharge and vapour return connections are preferably equipped with the dry disconnect coupling (NATO standard) metal cap . Materials of connections must be similar to that of the tank shell. It is recommended to maintain the shut off valve in addition to the dry disconnect coupling (figure 1).

Figure 1: **Disconnect coupling, 3 inch for liquid line (left side), 2 inch for the vapour line**



4.2.5

Connections should be adequately protected against possible impact that may occur during transport. This protection could be provided by means of a strong steel guard or by utilising the chassis of the vehicle. Both the liquid and vapour connections shall be clearly marked by their name (liquid/vapour).

To ensure that the foot valves/internal safety devices remain closed should either of the connection pipes be damaged, the design should be such that if the pipes are subjected to excessive strain, the tank shell remains undamaged.
Connection pipes, flanges and valves shall be suitable for the same test pressure as the tank shell. These connections should be provided with means to prevent unauthorised access.

4.3 Internal Vapour Return Pipe

4.3.1

The tank pipe shall be fitted with a NB 50 mm internal vapour return pipe which shall extend from the foot valve/internal safety device to the vapour space. The pipe shall be designed to restrict liquid entry and shall be supported so as to withstand any vibration during movement of the rail tank car.

5. Earthing connection

5.1.

Earthing connections shall be provided to prevent dangerous differences in electrical potential arising between the carrying tank, the body of the vehicle, the piping and the ground during the filling or discharging of the vehicle. Connections should be provided at each end of the tank and also adjacent to the discharge connections (figure 2).

Figure 2: **Earthing connection of a Railway Tank Car**

6. Insulation

6.1

Rail tank cars are to be insulated.

6.2

The insulating material shall:

a) Demonstrate minimum reactivity when in contact with ethylene oxide.
b) Be suitable for operating at the lowest ambient temperatures likely to be met in service.

6.3

The whole tank (with exception of the flanges and valves) has to be insulated.

6.4

All insulated flanges (e.g. manhole and bottom valve) shall have leak collectors preventing leaks to get into the main tank insulation. The insulation between the flange and the leak collector shall consist of foam glass.

6.5

The insulating thickness shall be minimum 100 mm.

6.6

The insulating material is to be covered by a stainless steel protection of minimum 0,8 mm thickness (weather barrier).

7. Instrumentation

Rail regulations normally permit the use of thermometers and pressure gauges and therefore these may be fitted to RTCs. However, if these devices are fitted, there is a need to ensure through regular examination and testing that they remain in proper working order. Instruments fitted to RTCs can produce misleading readings as a result of the effects of vibration during transit or the accumulation of small amounts of polymer.

If thermometers and pressure gauges are fitted, they should also be positioned in such a way that they are protected from external damage.

Appendix 4 Design and construction of road tankers and tank containers

1. Scope

1.1

Tanks for the carriage of ethylene oxide shall meet the International Regulations concerning the carriage of Dangerous Goods by road (ADR) for this specific product. The requirements that follow, give supplementary information and do not replace ADR requirements, they will apply for all new build road tankers/tank containers.

2. Materials of construction

2.1

For new road tankers/tank containers the tank shall be constructed of stainless steel meeting at least the following specification: AISI/SAE 304LN or the according equivalent for the approved Pressure Vessel Code. All materials shall be furnished with a minimum 3.1B certificate according to EN 10204.

2.2

Tank fittings and attachments in contact with ethylene oxide shall also be of the above-mentioned materials, and may not contain copper or alloys of copper and/or magnesium.

3. Tank construction

3.1

Tanks are to be designed according to an approved Pressure Vessel Code (for example ASME BPVC, AD-Merkblätter).

3.2

The Inner side of the tank must be pickled and passivated.
Grinding is only allowed at the bottom part of the tank to allow for complete emptying of the road tankers/tank containers.

3.3

Requirements for all pressure retaining welds are:

- Shall be 100 % radiographed.
- All Welding Procedure Specifications (WPS) and Procedure Qualification Records (PQR) must be made available for approval.
- All WPS and PQR must confirm with the approved Pressure Vessel Code.

3.4

Baffle plates are to be fitted

3.5

Reinforcement (backing) plates are required when the load bearing attachments (T-bar, anchor plates...) are not made of a stainless steel (see also “Material of construction”).

3.6
The design of the road tankers / tank containers must guarantee a complete unloading of the road tankers / tank containers. Criterion: less than 5 litres remaining product.

3.7
Nozzles on the shell should, as much as possible, be located away from the shell main weld seams.

3.8
For inspection purposes, the tank shall be fitted with one manhole not less than 500 mm diameter; the manhole shall be fully bolted and may have a hinged design (right hand side).

3.9
All gaskets (between flanges as well as the manhole) must be high purity compressed graphite laminated to tang stainless steel called grooved graphite OR camprofile gasket OR round spiral wound stainless steel type 304, filled with pure graphite (99,9 %). Depending on the flange design inner- and/or outer guide rings are required. (e.g. gaskets for tongue and groove flanges don't have guide rings).

3.10
Valves packing must be resistant to ethylene oxide and all valves must be of a fire-safe design.

3.11
Tanks must be designed so that there are no pockets that can trap liquid during discharge.

3.12
The two screw threaded inlet points at each and of the tank, top centre (to permit the initial pressure test of the tank), shall be seal welded.

3.13
The only openings allowed in the tank are :

- One manhole;
- Two foot valves;
- Two threaded inlet points

3.14
The welds at the outer side of the shell shall be pickled and passivated.

3.15
In order to protect welds for stress corrosion cracking, all stainless steel surfaces can be coated.

4. Equipment

4.1 Pressure relief devices

Any pressure relief design must conform to ADR and IMO regulations. If pressure relief valves are fitted, they shall be preceded by a bursting disc, which must be suitable for use under safety valves. The space between valve and disc could be fitted with a pressure gauge for checking the integrity of the disc.
Bursting discs shall have direct access to the vapour space of the tank. Pressure relief valves shall be of the spring loaded type. The discharge from pressure relief valves shall be so arranged that any escaping vapour cannot impinge directly on the tank shell.
Bursting discs and pressure relief valves shall be constructed of stainless steel.

4.2. Filling / Discharge and Vapour Return fittings

4.2.1.

The tank must be fitted with an NB 80 mm filling/discharge pipe with an 80 mm shut off valve. The vapour return connections shall be a NB 50 mm pipe, fitted with a NB 50 mm shut off valve. Valves shall be of an approved make and type.

4.2.2

In addition, a quick closing internal safety device shall be fitted in the tank shell for the liquid filling/ discharge connection. The device shall be capable of being operated remotely. The device shall also close automatically in the event of a hose rupture or the inadvertent movement of the road tankers/tank containers. The valve actuator shall consist of a hydraulic system.

4.2.3

Both the filling / discharge and vapour return connections must be able to be closed by means of a blind flange. Materials of connections must be similar to that of the tank shell.

4.2.4

Both the filling / discharge and vapour return connections are equipped with the dry disconnect coupling (NATO standard) and a dust cap or pressure retaining cap.. Materials of connections must be similar to that of the tank shell.

4.2.5.

Connections should be adequately protected against possible impact that may occur during transport. This protection could be provided by means of a strong steel guard or by utilising the chassis of the vehicle. For tank containers, all connections should be contained within the ISO framework. Both the liquid and vapour connections shall be clearly marked by their name (liquid/vapour).
To ensure that the foot valves/internal safety devices remain closed should either of the connection pipes be damaged, the design should be such that if the pipes are subjected to excessive strain, the tank shell remains undamaged. Connection pipes, flanges and valves shall be suitable for the same test pressure as the tank shell. These connections should be provided with means to prevent unauthorised access.

4.3. Internal Vapour Return Pipe

4.3.1

The tank pipe shall be fitted with a NB 50 mm internal vapour return pipe which shall extend from the foot valve / internal safety device to the vapour space. The pipe shall be designed to restrict liquid entry and shall be supported so as to withstand any vibration during movement of the road tankers/tank containers.

5. Earthing connection

5.1

Earthing connections shall be provided to prevent dangerous differences in electrical potential arising between the carrying tank, the body of the vehicle, the piping and the ground during the filling or discharging of the vehicle. Connections should be provided at each end of the tank and also adjacent to the discharge connections.

6. Insulation

6.1

Road tankers / tank containers are to be insulated.

6.2

The insulating material shall:

a) Demonstrate minimum no reactivity when in contact with ethylene oxide.
b) Be suitable for operating at the lowest ambient temperatures likely to be met in service.

6.3

The whole tank (with exception of the flanges and valves) has to be insulated.

6.4

All insulated flanges (e.g. manhole and bottom valve) shall have leak collectors preventing leaks to get into the main tank insulation. The insulation between the flange and the leak collector shall consist of foam glass.

6.5

The insulating thickness shall be minimum 100 mm.

6.6

The insulating material is to be covered by a stainless steel protection of minimum 0,8 mm thickness (weather barrier).

7. Instrumentation

Temperature and pressure measuring devices must be fitted. Surface temperature measurement of the tank bottom is recommended for new equipment. The pressure measuring device shall be installed in the vapour phase.Both devices shall be suitably protected.

Appendix 5 General instructions for ethylene oxide drivers

Contents

1. Introduction 31
2. Definitions 31
3. Product information 32
3.1 Road transport classification 32
3.2 Alternative product names 32
3.3 Chemical formula 32
3.4 Flammability 33
3.5 Chemical reactivity 34
3.6 Decomposition 34
3.7 Polymerisation 34
4. Health hazards 34
4.1 Inhalation of the vapour 34
4.2 Skin contact with liquid ethylene oxide 35
4.3 Eyes 35
5. Personal safety equipment 35
6. Loading / unloading 36
7. Transportation 37
7.1 Placarding / labelling 37
7.2 Provision of instructions in writing 37
7.3 Routing 37
7.4 Safe parking 37
7.5 Severe weather 38
7.6 Delays 38
7.7 Pressure and temperature checks during longer journeys 38
7.8 General remarks 38
8. Emergency procedure 38
8.1 Increase of temperature or pressure in the tank 38
8.2 Vapour / liquid leakages and / or fire 39
8.3 In the case of accident involving injury or immobilisation of the vehicle, but no leakage or fire 39
Annex 1 40
Total pressure of transport containers 40
Annex 2 41
Tremcard - Instructions in writings 41

1. Introduction

Ethylene oxide (EO) is flammable, chemically reactive and toxic, having harmful properties as to health and to the environment. Nevertheless, it can be handled, transported and stored in a safe way, provided that appropriate precautions are observed.

The ethylene oxide driver has an important job to do. He is accompanying the shipment and is, during the entire transport, in charge of the technical care of his vehicle and the product. It is essential that the driver is totally familiar with the nature of the potential hazards which may be presented by ethylene oxide during transport, and the action to be taken in the event of an emergency.

These general instructions for ethylene oxide drivers have been prepared by the EO Distribution Working Group of CEFIC (Conseil Européen de l'Industrie Chimique = European Chemical Industry Council). They have been accepted by all European EO producers within CEFIC as a uniform set of instructions for issue to all ethylene oxide drivers, and as the basis for specific product training for drivers.

The objective in preparing a uniform set of instructions for all drivers is to ensure that ethylene oxide is handled and transported as safely as possible. It should be noted that individual ethylene oxide producers may stipulate additional requirements where they see fit for safe transport.

Before drivers are permitted to convey ethylene oxide they must:

a) already be in possession of a valid ADR drivers certificate, dangerous goods, class 2 for international transport, or an equivalent document,
b) have attended a specific, additional training course for ethylene oxide familiarisation organised by an ethylene oxide producing company affiliated to Cefic.

Drivers who have successfully completed an ethylene oxide training and associated test will receive an Ethylene Oxide training certificate giving the drivers name.

The Training Certificate will be mutually acceptable to all ethylene oxide producing companies affiliated to CEFIC.

Drivers without an Ethylene Oxide Training Certificate will not be accepted for the transport of ethylene oxide.

2. Definitions

Boiling point	The specific temperature at which a liquid converts into the gas/vapour phase. This temperature depends on the pressure above the liquid.
Vapour pressure	The pressure, above the liquid, caused by vapour in equilibrium with that liquid.
Flash point	Lowest temperature at which vapour above the liquid can be ignited in combination with oxygen from the air.
Lower explosion limit	The minimum concentration of a substance in air, at which ignition is possible. At lower concentrations the mixture is too "lean".
Upper explosion limit	The maximum concentration of a substance in air, at which ignition can take place. At higher concentrations the mixture is too "rich".
Decomposition	A reaction in which a substance breaks down into several other parts (components). Very often considerable heat is produced at the same time.
Polymerisation	A chemical reaction in which individual molecules of the same substance combine together to produce a much larger molecule (polymer). Considerable heat is often produced at the same time.

Exothermic	A reaction with formation of heat e.g. polymerisation with generation of heat is an exothermic reaction.
ADR	European Agreement Concerning the International Carriage of Dangerous Goods by Road.
RID	Regulations concerning the International Carriage of Dangerous Goods by Rail.
IMO	International Maritime Organisation. (Organisation for international transport by sea, including international ferries).

3. Product information

3.1 Transport classification

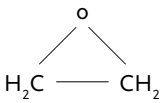
ADR/RID:
Description: Ethylene Oxide with nitrogen up to a total pressure of 1 MPa (10 bar) at 50°C
Class: Class 2, TF
Hazard identification number: 263
Substance identification number: 1040

UK carriage of dangerous goods by road regulations:
Description: as above
UN Number: 1040
Class: 2.3
Subsidiary hazard: 2.1
Emergency action code: 2 PE

3.2 Alternative product names

Ethylene oxide
Ethene oxide
1,2 - epoxyethane
(Normal abbreviation: EO)

3.3 Chemical formula

C_2H_4O or 

Molecular weight: 44.05

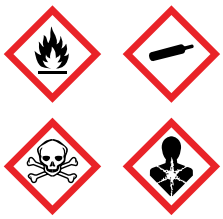
3.4 Classification and labeling:

Classified as dangerous according to the criteria of Regulation (EC) No 1272/2008

CLASS CATEGORY - HAZARD STATEMENTS

Flammable Gas category 1 - H220: Extremely flammable gas.
Pressurised. Gas - Liquefied gas - H280: Contains gas under pressure; may explode if heated.
Carcinogen. category 1B - H350: May cause cancer.
Mutagen category 1B - H340: May cause genetic defects.
Acute Toxicity. category 3 - H331: Toxic if inhaled.
Acute Toxicity. category 4 - H302: Harmful if swallowed.

Eye Irritation category 2 - H319: Causes serious eye irritation.
STOT SE category 3 - H335: May cause respiratory irritation.
Skin Irritation. category 2 - H315: Causes skin irritation



LABELLING ACCORDING TO REGULATION EC NO 1272/2008 (CLP)

Signal word: Danger

H-STATEMENTS

H220 Extremely flammable gas.
H280 Contains gas under pressure; may explode if heated.
H350 May cause cancer.
H340 May cause genetic defects.
H331 Toxic if inhaled.
H302 Harmful if swallowed.
H319 Causes serious eye irritation.
H335 May cause respiratory irritation.
H315 Causes skin irritation.

P-STATEMENTS

P210 Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P280 Wear protective gloves and eye protection/face protection.
P261 Avoid breathing.
P311 Call a POISON CENTER or doctor/physician.
P304 + P340 IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P302 + P352 IF ON SKIN: Wash with plenty of soap and water.

SUPPLEMENTAL INFORMATION

Restricted to professional users.

3.5 Flammability

Ethylene Oxide has a flash point of -18°C. This means that at -18°C and higher there is a flammable vapour present above the ethylene oxide liquid. The vapour of ethylene oxide is flammable in air at concentrations at or above 2.6 % ethylene oxide in air. (Lower explosion limit = LEL). There is no upper flammable limit as normally conceived in that exothermic decomposition replaces combustion at the higher ranges up to 100 % ethylene oxide vapour.

Mixtures of flammable vapour in air usually have an upper explosion limit (UEL). At the upper explosion limit, the gas mixture is normally too “rich” for ignition, as there is insufficient oxygen available in the air. However, ethylene oxide has no upper explosion limit. So, at concentrations of ethylene oxide in air above 2.6 %, the vapours of ethylene oxide are always flammable or explosive.

Due to its low boiling point (10.5°C) and flammability, ethylene oxide is in some respects similar to LPG. However, an important difference is that ethylene oxide is fully miscible with water. Another important difference is that ethylene oxide requires very little energy for ignition.

Ethylene oxide diluted with water can still give rise to a flammable vapour. Even a 1 % solution of ethylene oxide in water has a flashpoint of 22°C. Therefore all spills need to be diluted at least 100-fold.

As much water as possible should always be used to dilute any ethylene oxide leakage. If insufficiently diluted solutions enter drains or sewers there may still be a flammable risk.

Ethylene oxide auto-ignites in air if the temperature reaches 429°C.

3.6 Chemical reactivity

Ethylene oxide is a highly reactive chemical which can react especially in the presence of a catalyst, with compounds such as water, alcohols, ammonia, amines, and organic acids. These reactions can be self-accelerating and generate considerable quantities of heat. Therefore it is most important to ensure inadvertent mixing with other chemicals, including water does not occur.

It is the reactivity of ethylene oxide which makes it so important as the feedstock for the preparation of other useful chemicals. The most important derivative is ethylene glycol, which is used in antifreeze and for the manufacture of polyester fibres. Other ethylene oxide derivatives are used as surfactants and solvents.

Ethylene oxide itself is used as a disinfectant, sterilising agent in controlled circumstances.

3.7 Decomposition

When exposed to temperatures above 560°C the vapours of EO above the liquid decompose spontaneously and can cause an explosion. No oxygen is required. Decomposition and explosion can be prevented by diluting the vapours with a suitable inert gas, typically nitrogen.

The nitrogen must be very pure, as follows:

- purity 99.99% minimum
- oxygen 20 ppm maximum
- water 5 ppm maximum

3.8 Polymerisation

Liquid ethylene oxide is very susceptible to polymerisation which can be initiated by acids, bases or catalysts such as metal oxides and anhydrous chlorides of iron, aluminium and tin. Therefore it is most important to maintain clean equipment when handling ethylene oxide, and to ensure inadvertant mixing with other chemicals does not occur.eg: during cleaning activities...
The polymerisation reaction can generate considerable heat and, if the temperature cannot be controlled, it will accelerate leading to vaporisation of unreacted ethylene oxide and possibly to explosive decomposition of the vapour.
Slow polymerisation can occur, producing solid polymer, which is thermally stable. Examples of slow polymerisation can sometimes be found inside loading , unloading lines and filters.

4. Health hazards

EO is recognised as a direct acting mutagen and has the potential to cause mutations in cells of exposed human tissue. Animal experiments indicate that EO should be regarded as probably carcinogenic to humans.

The regulations concerning the personal exposure limits for EO in air vary between different European countries. At the present time, values typically vary between 1 and 10 ppm.

4.1 Inhalation of the vapour

Inhalation of EO vapour irritates the respiratory organs and causes accumulation of fluid in the lungs. The symptoms may develop some hours later and are exacerbated by physical exertion.
The injured person must rest and therefore admission into a hospital is essential. When exposed to higher vapour concentrations, nausea and vomiting can be observed as first symptoms.

First aid: fresh air, rest and call a doctor at once!

4.2 Skin contact with liquid ethylene oxide

Liquid EO when spilled on the exposed skin may produce reddening. However, longer contact could result in damage of the skin.

Figure 3: **Blister and skin burns caused by an Ethylene Oxide Water mixture**

Solutions of EO in water, depending on the EO concentration and exposure time can cause severe chemical damage. Concentrations of about 50% appear to be most dangerous. However, the skin may become irritated by EO concentrations as low as 1% in water or by EO vapour (figure 3).

Intensive skin contact may result in a chronic allergic eczema.
First aid: Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a doctor.

4.3 Eyes

EO vapour irritates the mucous membrane of the eyes.
Liquid EO and solutions of EO in water can cause severe burns and may cause permanent corneal damage.

First aid: Irrigate eyes for 10-15 minutes and call a doctor at once!

IF IN CONTACT WITH EO, MEDICAL ATTENTION MUST ALWAYS BE SOUGHT AT ONCE.

5. Personal safety equipment

If exposure to liquid and/or inhalation of vapour is possible, adequate personal protection must be worn.
As a minimum, the following should be used:

- safety goggles
- resistant gloves (e.g. butyl rubber)
  Natural rubber, PVC or nitrile rubber may NOT provide adequate resistance.
- suitable respiratory protective device. (Compressed air/Oxygen apparatus or AX-filter)

Review your supplier eSDS for more information.
Clothing for spill and fire:

- wear full protective clothing EO resistant gloves under gauntlet type Butyl rubber gloves/
- safety boots and approved positive pressure breathing apparatus
- remove contaminated clothing immediately, preferably under safety shower / fire hose spray
- destroy contaminated clothes, shoes and leather items

6. Loading / unloading

Loading and unloading facilities should be situated at a safe distance from storage tanks. For reasons of polymerisation, contamination must be avoided. Therefore, only dedicated road tankers, tank containers and rail tank wagons must be used for ethylene oxide and they must be held under nitrogen pressure at all times.

Externally, each road vehicle should be inspected visually before filling to ensure that it is in a good mechanical condition. The vapour space must always be sampled and tested for oxygen content (maximum 0.3%). The leakproofness of loading/unloading valves must be checked. Before connection, the tank has to be earthed and hose connections purged with nitrogen. Filling of the tank must not exceed 0.78 kg/litre of capacity.

After loading, the tank is to be pressurised with nitrogen. Annex 1 indicates the equilibrium maximum and minimum total pressure to:

- ensure that the gas phase remains inerted even if heated to 50° C
- ensure that the pressure does not rise to above 10 bars on heating to 50° C.

When filling transport tanks, an appropriate allowance should be made to the pressures indicated to allow for equilibration between the gas and liquid phases after the tank is sealed. This allowance will vary depending upon loading conditions, but may be of the order of 0.5- 1.0 bar. Even after unloading, ethylene oxide tanks should be maintained at a minimum gauge pressure of 3 bars by using nitrogen.

Drivers must report back to the principal/consignor if they find that unloading conditions do not meet the necessary safety requirements.

Tanks which have been stored for a long time may have valves choked by polymer. If this occurs the valve should be closed and expert advice sought. Tanks should be used regularly or cleaned if stood unused for long periods.

Loading and unloading facilities at terminals should have a remote controlled shut-off valve between the storage tanks and the loading/unloading vehicles.

Loading/unloading procedure: key points

When loading or unloading, the following points must be observed.

- Earthing: DDuring loading or unloading, the vehicle must be earthed. The earthing cable should be fitted and a satisfactory earth established before loading or unloading connections are made. Similarly, at the end of the transfer operation, the loading or unloading connections must be disconnected before the earthing cable is unfastened.
- Tank vehicle: Make sure that before loading the oxygen content is always measured.
  This MUST be lower than 0.3% vol.
- Breathing: During connecting/disconnecting, breathing protection should be worn.
- Connections: After connection, the flexible hoses must be pressurised with nitrogen and the connections checked for leaks before transfer is allowed to commence by means of a soap test or equivalent measurement.

Before disconnection, the flexible hoses must be purged with nitrogen.

7. Transportation

7.1 Placarding / labelling

Loaded and also empty uncleaned EO vehicles must be provided with hazard labels in order to comply with the appropriate transport regulations. For example, for ADR transport, the following should be provided:

- danger label 2.3. (toxic gas)
- danger label 2.1. (flammable gas)

Figure 4: **Dangerous goods label and hazard identification number**

Furthermore the hazard identification number (263) and the substance identification number (1040) must be marked on the vehicle (figure 4).

7.2 Provision of instructions in writing

Drivers engaged in the transport of loaded and also empty unclean EO vehicles must be in possession of transport emergency cards in the appropriate languages depending upon the routing and on the final destination of the vehicle. Copies of the official Emergency Response Intervention Card (ERIC) are included in Annexe 2.

7.3 Routing

The transport of ethylene oxide has to follow the ADR-regulations. According to this the route must be selected carefully. As far as possible,the route should utilise motorways and avoid inhabited areas.
The preferred route should be known by all involved parties.

7.4 Safe parking

Drivers must ensure that the vehicle is either supervised or is parked in a secure place.
No potential source of heat or fire must exist in the vicinity, and the vehicle must be capable of being easily removed in an emergency.

Drivers must inform the haulier of their overnight parking location. The overnight parking locations must be selected in accordance with regulations (for example ADR).

7.5 Severe weather

When severe weather conditions are experienced during transport, for example icy roads, snow or poor visibility, the delivery should be stopped at the next suitable parking place.

7.6 Delays

All delays during transport, whether due to severe weather conditions, breakdown or other reasons must be reported to the consignor as soon as possible.
Transport accidents must also be reported to the consignor as soon as possible.

7.7 Pressure and temperature checks during longer journeys

For road transport longer than 24 h, the pressure and/or temperature of the tank contents should be checked regularly and recorded on a checklist or in a logbook.

7.8 General remarks

Although vehicles and tanks are maintained in good condition and accompanied by a skilled experienced driver, once on route the driver can be confronted with unforeseen situations or problems which he cannot handle on his own.
If there are technical or safety problems concerning the product during the journey or at customers premises, drivers should immediately contact their principals by phone.

8. Emergency procedure

If the appropriate transport regulations are complied with, and the requirements set out in this document are adhered to, the risk of a transport emergency involving ethylene oxide is very small. Nevertheless, it is essential that drivers should be aware of the appropriate action to be taken should an emergency occur.

8.1 Increase of temperature or pressure / decrease of pressure in the tank

During the journey, the temperature of the ethylene oxide should not increase more than 3°C in 24 hours. Normally the pressure in the tank should not increase, and under normal circumstances will only do so if the temperature increases.
If a more rapid rate of temperature increase is observed or a temperature of 25°C is reached, or a significant increase or decrease of pressure is observed, apply the following emergency procedure:

1. Do everything possible to drive the vehicle to an open space away from buildings and populated areas. Park and leave the vehicle, taking with you:
   any temperature / pressure records and
   the transport documents.
2. Alert everybody in the surroundings and keep people away.
3. Contact immediately the local Police and the Fire Brigade.
4. Ensure that the consignor is notified as soon as possible and provide detailed information - when the increase started, how long has the temperature/ pressure been increasing, what is the present temperature / pressure.
5. Assist the local authorities.
6. Check whether the temperature is still increasing and/or pressure is still increasing or decreasing). Should the temperature reach 40°C, or if the pressure approaches the maximum allowed working pressure of the tank, or the rate of temperature rise accelerates quickly, e.g. 2° - 3°C per 5 - 10 minutes, then immediate evacuation of the surrounding area is required.

Urgently request the local Police to evacuate the surrounding area immediately and move people as far as possible away from the tank.

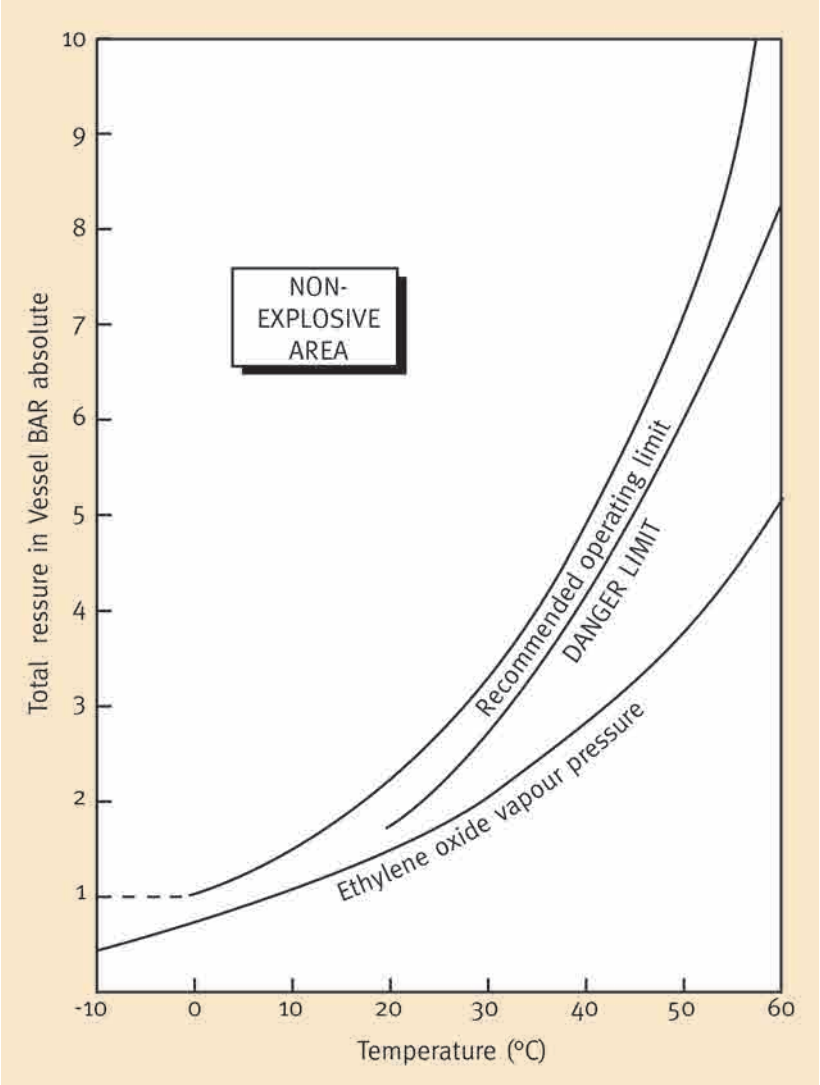
8.2 Vapour / liquid leakages and / or fire

1. Abandon the vehicle immediately / turn off all electrical devices (truck main switch, radio, etc).
2. Alert everybody in the surroundings and keep people as far away from the vehicle as possible.
3. Contact immediately the local Police and the Fire Brigade.
4. Ensure that the consignor is notified as soon as possible.

8.3 In the case of accident involving injury or immobilisation of the vehicle, but no leakage or fire

1. Contact immediately the local Police.
2. Ensure that the consignor is notified as soon as possible.
3. If the vehicle cannot be moved, the emergency orange flashing lights should be positioned to protect the front and rear of the vehicle. Checks of the temperature and pressure of the tank should continue to be made and recorded.

Annex 1
Total pressure of transport containers



Source: J.H. Burgoyne, K E Bett and R Lee, I Chem E, Symposium Series No 25, (1963)
The Explosive Decomposition of Ethylene Oxide Vapour Under Pressure Part 2

Annex 2
ERIC card (Version 2.12)

Substance: ETHYLENE OXIDE WITH NITROGEN
UN Number: 1040
HIN: 263
ADR Label: 2.3+2.1
ADR Class: 2
Classification Code: 2TF
Packing Group:
ERIC: 2-12

Emergency Response Information
Flammable toxic liquefied gas

1. Characteristics

- Hazardous to skin, eyes and air passages.
- Forms explosive mixture with air.
- Toxic by inhalation or skin absorption.
- The gas is absorbed or readily dispersed by water fog/spray.

2. Hazards

- Gives off toxic or irritant gases or fumes when burning.
- Heating of container(s) will cause pressure rise with risk of bursting and immediate release of expanding toxic vapour cloud which may ignite, leading to explosion (VCE) and creation of a pressure wave.
- Contact with liquid will cause frostbite and severe damage to eyes.
- The gas may be invisible and may enter sewers, basements or confined spaces.

3. Personal protection

- Gas tight suit.
- Protect personnel from radiated heat with water fog curtain or other heat protective measures.
- Insulating undergarments and thick textile or leather gloves.
- Consider wearing standard fire fighting clothing underneath the suit.

4. Intervention Actions

4.1 GENERAL.

- No smoking, eliminate ignition sources.
- PUBLIC SAFETY HAZARD - Warn people nearby to stay indoors with doors and windows closed. Stop any ventilation. Consider evacuation of people in immediate danger.
- Keep upwind. Put on protective equipment before entering danger area.
- Minimise number of personnel in risk area.
- Warn people to leave and not to re-enter basements, sewers or other confined spaces.

4.2 SPILLAGE

- Stop leaks if possible.
- Check explosive limits.
- Use low sparking hand tools and intrinsically safe equipment.
- Knock down or disperse gas cloud with water spray.
- If substance has entered a water course or sewer, inform the responsible authority.
- Ventilate sewers and basements where there is no risk to personnel or public.
- In the absence of specialist advice, drench spillage with water spray to assist evaporation and absorb gas but avoid unnecessary run off which will cause pollution.

4.3 FIRE (INVOLVING THE SUBSTANCE)

- Keep container(s) cool with water.
- Cut off gas supply if safe to do so.
- Do NOT extinguish leaking gas flame unless ABSOLUTELY necessary.
- Work from protected position to reduce risk to personnel. Use unmanned monitors or lances.
- Extinguish with water fog (spray) or dry powder.
- Do not use water jet to extinguish.
- Use water spray to knock down fire fumes if possible.
- Avoid unnecessary run-off of extinguishing media which may cause pollution.

5. First Aid

- If substance has got into eyes, wash out with water for at least 15 minutes and seek immediate medical attention.
- Remove contaminated clothing immediately and drench affected skin with plenty of water.
- Persons who have been in contact with the substance or have inhaled fumes should get immediate medical attention. Pass on all available product information.
- In case of burns, immediately cool affected skin for as long as possible with cold water. Do not remove clothing adhering to skin.
- Mouth to mouth resuscitation should be avoided. Use alternative methods, preferably with oxygen or compressed air driven apparatus.
- Thaw frosted parts carefully with cold water.

6. Essential Precautions For Product Recovery

- Do not use standard recovery equipment. Seek specialist advice immediately.

7. Precautions After Intervention

7.1 UNDRESSING

- Drench contaminated suit and breathing apparatus with water before removing facemask and suit.
- Use chemical protection suit and self contained breathing apparatus while undressing contaminated co-workers or handling contaminated equipment.

7.2 EQUIPMENT CLEAN UP

- Seek specialist advice before leaving incident.

Appendix 6 Inspection of transport equipment

1. Routine inspection of road tankers and tank containers at loading terminals

Where relevant, applicable regulations (ADR/RID/IMO) are mentioned.

If any of the following conditions are not met, the loading operation must be stopped and the situation rectified before loading is allowed to continue.

a. Before loading

1. Are there any visual objections on the truck against safe driving? (e.g. lights and tyres in good condition)
2. Is there a valid ADR-certificate for ethylene oxide?
3. Has the driver a valid ADR licence for the transport of dangerous substances and a valid EO specific training certificate?
4. For tank containers, is the tank container plate valid?
5. Are all 'dangerous goods' labels fitted, are the identification numbers 263/1040 attached. For road transport: is the Tremcard in all required languages on board?
6. Does the driver possess all the items of protective clothing and safety equipment? (as specified by the Tremcard)
7. Determine the maximum payload based on:
   - tare weight
   - country of destination
   - transport mode
   - maximum filling degree
8. Are all the valves closed upon arrival?
9. Is the tank placed at the correct loading position?
10. Are the wheels of the tank (or the rail tank car) blocked by wheel blocks or other tools?
11. Do all valves function correctly?
12. Is the oxygen concentration below 0.3 %? The tank must then be brought under a nitrogen and ethylene oxide atmosphere as per Annex 1 of Appendix 5.

b. Whilst loading

1. Is the maximum degree of filling not exceeded?

c. After loading

1. Is the vessel pressurised with nitrogen to a pressure suitable for transport?
2. Is the maximum gross weight not exceeded? (check by weighbridge)
3. Is a leakage test performed (bottom valve and end valve)?
4. Are all valves closed and blinded, with all bolts in place or are all dry disconnect couplings / metal caps in place?
5. Are all seals or locks in place?

2. Routine inspection of rail tank cars (RTCs) at loading terminals

If any of the following conditions are not met, the loading operation must be stopped and the situation rectified before loading is allowed to continue.

a. Before loading

1. Is the rail track secured to prevent collision?
2. Is the Rail Tank Car dedicated for ethylene oxide transport?
3. Is the inspection date not exceeded?
4. Are all 'dangerous goods' labels fitted and are the identification numbers 263/1040 attached?
5. Is the tare weight in your possession?
6. Are all the valves properly closed upon arrival?
7. Is the emergency bolt, which opens the bottom valves mechanically, in a safe position on the RTC chassis? (This emergency bolt may only be used to open the bottom valves in the case of an emergency. It is strictly forbidden to start loading with an emergency valve blocked by the emergency bolt.)
8. Is the RTC placed at the right loading position?
9. Are the wheels of the RTC blocked by wheel blocks or other tools?
10. Do all valves function correctly?
11. Is the oxygen concentration below 0.3%?

The tank must then be brought under a nitrogen and ethylene oxide atmosphere as per Annex 1 of Appendix 5.

b. Whilst loading

1. Is the maximum degree of filling not exceeded?

c. After loading

1. Is the RTC pressurised with nitrogen to a pressure suitable for transport?
2. Is the maximum gross weight not exceeded ?
3. Is a leakage test performed (bottom valve and end valve)?
4. Are all valves closed and blinded, with all bolts in place or are all dry disconnect couplings / metal caps in place?
5. Are all seals or locks in place?

3. Initial inspection of road tankers, tank containers and rail tank cars (RTCs)

Before road tankers, tank containers or RTCs are first introduced to ethylene oxide service, or reintroduced to service following maintenance or repair, a responsible person from the loading company should seek confirmation of the following items:

a. is the transport equipment identical in all respects with the general arrangement engineering drawing?
b. have the correct packings and gaskets been fitted? (for example, spiral wound, stainless steel type 304, graphite-filled or tanged graphite)
c. has the tank been properly cleaned? (grit blasting and vacuum cleaning for carbon steel tanks, with no rust remaining; degreasing for stainless steel tanks)
d. do all valves function correctly? (Hydraulic bottom valve indicator, figure 5)

It is recommended that for the first loading of a new or repaired vehicle a special "take into service procedure" will be conducted. This should include pressure tightness tests with i.e. nitrogen before loading and also EO leak tests after the start of loading.

Figure 5: **Hydraulic bottom valve indicator**

4. Maintenance of transport equipment

During operations, unscheduled maintenance of the transport equipment may be necessary if quick closing valves or bottom valves on road tankers or RTCs cease to function correctly. Similar difficulties may be experienced with excess flow valves on tank containers and Road tank cars. Valves may become blocked with small amounts of polymer.

Customers should be instructed to immediately report to the consignor any difficulties which are experienced with the operation of valves. The provision of an information tag on the returning transport equipment identifying the difficulty can be of assistance.

Consignors of RTCs should maintain close liaison with local railway authorities on all matters concerning the running gear of RTCs.

Appendix 7 Example of a checklist for Rail Tank Cars

The following conditions have to be carefully checked (proposed Checklist) and if one or more of these are not met, the loading operation has to be stopped and the situation rectified before loading continues.

Example of Checklist rail tank cars

Rail tank cars liquids - inspection prior to departure

1. IDENTIFICATION							
1.1	Wagon number:						
1.2	Wagon empty / loaded:						
1.3	Which substance loaded / unloaded:						
1.4	Hazard Identification Number / UN-number:						
1.5	Substance permitted for transport:	YES		NO		☯	
1.6	Next periodic inspection:						
1.7	Last overhaul underframe:						
1.8	Inspection dates valid:	YES		NO		☯	

2. GENERAL CONDITION		YES	NO	N/A	☯
2.1	Visual damage (insulation,panel,underframe,equipment...)				
2.2	Wagon marked with non conformity note Railways If yes: Which model of note: Which defect / damage:				
2.3	Wagon and connections free from leakages/substance residues.				
2.4	General condition of wagon OK				

3. LABELLING / MARKING		YES	NO	N/A	☯
3.1	Markings inscription panel/underframe and tank properly readable				
3.2	Prescribed (RID) danger labels fitted (L/R)				
3.3	Prescribed (RID) orange marking(Hazard Identification Number / UN-number) fitted (L/R)				
3.4	Substance name marked on wagon (L/R)				
3.5	Labelling/marking removed if cleaned (L/R)				
3.6	Specific markings (emergency telephone numbers,presence of nitrogen, under atmospherical air etc.) (L/R)				
3.7	Operation instructions bottom valve present				

4. BOTTOM UNLOADING/LOADING SYSTEM		YES	NO	N/A	☯
4.1	Visual damage/defect unloading/loading system				
4.2	Bottom valve in closed condition				
4.3	Outlet valve (liquid and vapour return) in closed condition				
4.4	In case of vapour return connection below:vapour return marked				
4.5	Suitable gaskets in dust caps/blind flanges				
4.6	Outlet connections fitted with tightened dust caps.				
4.7	Outlet connections fitted with blindflanges with a tightened bolt in each bolt hole.				
4.8	Dustcaps fitted with a chain				
4.9	Blindflanges fitted with a chain				
4.10	Operation system outletvalves secured with securing pins				
4.11	Operation system bottomvalve secured with securing pins				
4.12	Securing pins fitted with chains				
4.13	Hydraulical system free of any leaks				
4.14	Valves sealed				
4.15	Earthing point present				
5. UNLOADING/LOADING SYSTEM ON TOP		**YES**	**NO**	**N/A**	☯
5.1	Visual damage/Defect of unloading/loading system on top				
5.2	All top valves closed				
5.3	All top connections (including those under the protection cap) properly closed (tightened bolt in each bolt hole of flange)				
5.4	Used top connections fitted with suitable gaskets				
5.5	Top connections marked (colour code or name)				
5.6	Protection cap (if present) closed and secured				
5.7	Man hole fitted with suitable gasket in proper condition				
5.8	Man lid properly closed:all swing bolts properly tightened				
5.9	Man lid sealed				
6. TANK EXTERIOR		**YES**	**NO**	**N/A**	☯
6.1	No substance residues on top of tank (no odour..)				
6.2	Walkway on top in proper condition and safely accessible				
6.3	Insulation in proper condition				
6.4	Ladder in proper condition				

7. UNDERFRAME		YES	NO	N/A	☯
7.1	Crossing bridge in proper condition				
7.2	Steps in proper condition				
7.3	Braking shoes in proper condition				
7.4	Braking hoses/couplings in proper condition				
7.5	Hand brake in proper condition				
8. LEAK TESTING		**YES**	**NO**	**N/A**	**☯**
8.1	Leak test performed and:				
	8.1.1 Bottom valve leak tight				
	8.1.2 Outlet valve leak tight				
9. REMARKS					
Inspected by:		Date:			

☯: *also to be inspected prior to loading*

Appendix 8 A safety visit scheme for the reception and storage facilities at ethylene oxide customers

1. Introduction

1.1

The purpose of this scheme is to ensure that a sufficient level of equipment is available and appropriate operating procedures are in place at customer's premises to permit the safe unloading and storage of ethylene oxide.

2. Scope

2.1

This visit scheme shall apply to the reception of EO by road or rail at all customers.

2.2

The principal objective is to ensure that the transfer of EO from the delivering vehicle to the storage tank can be carried out safely. However, because the storage system and procedures may affect the safety of the unloading operation, these also need to be considered.

2.3

The visit should also be used to:
Assess and record any changes in policy, attitudes or equipment since the previous visit.
Obtain customer's comments on the transport operation and equipment being used.

3. Conduct of the visit

3.1

It is recommended that the checklist shown in Annex 1 is used during the visit as an aid to ensure that all relevant items are considered.

3.2

The guidance notes (Annex 2) provide an explanation of the checklist, and recommended minimum standards in certain cases.

Annex 1
Ethylene oxide unloading / storage checklist

CUSTOMER:
DATE:
ADDRESS:
PERSONS INTERVIEWED:
VISITED BY:

1. The unloading area

1.1 Ease of access; are crash barriers or buffer installed?
1.2 Housekeeping
1.3 Separation from other activities
1.4 Ability to mobilise road tanker / RTC in case of emergency
1.5 Facilities to isolate area and restrict access
1.6 Water sprays / Fire fighting systems
1.7 Electrical classification, defined explosive proof area?
1.8 Minimum safety distances should be 15 metres between the offloading point and storage.
- Ignition source
- Boundary fence / or other facilities

1.9 Adjacent offloading points
1.10 Hoses/loading arms
1.11 Earthing Point
1.12 Pipe damage protection
1.13 (Other vehicles and trucks movements) Could the unloading area be isolated from traffic during unloading operation? Could the railway track be blocked? Are breakaway couplings present?
1.14 Adequate lighting
1.15 Is a drive away protection installed what type? (Only for road transport)
1.16 Is the unloading area equipped with a drain system to deal with a spillage of EO and or polluted water during emergency response actions?
1.17 Is the unloading area equipped with an explosive atmosphere detection and alarm?

2. The unloading operation

2.1 Personnel and equipment
- 2.1.1 The presence of customer's operator
- 2.1.2 Operator's experience, training and seniority
- 2.1.3 Deputy availability
- 2.1.4 Hose testing and renewal policy
- 2.1.5 Fixed loading arm testing and maintenance
- 2.1.6 Availability of suitable safety equipment
- 2.1.7 Communication system

2.2 Operations
- 2.2.1 Written procedures (See Section 6 below).
- 2.2.2 Hose purging and leak testing
- 2.2.3 Sampling procedure
- 2.2.4 Atmospheric/personal EO monitoring
- 2.2.5 Method of unloading
- 2.2.6 Use of rail hook
- 2.2.7 Safeguards for pump
- 2.2.8 Emergency response
- 2.2.9 Emergency shut down

3. Nitrogen supply

3.1 Source of nitrogen
3.2 Protection of nitrogen purity

4. The storage tank

4.1 Siting
- Bunded
- Shared
- If shared, with what?
- Separation distances
- Emergency disposal facilities, drain system
- Is the tank farm equipped with an explosive atmosphere detection and alarm?

4.2 Construction
- Material of construction:
- Insulated
- Uninsulated
- Refrigerated
- Water sprays / Fire fighting systems
- Earthed
- Design pressure
- Maximum allowed working pressure
- Date and type of last test / inspection
- Dip inlet pipe

4.3 Relief valves
- Separate
- Combined with interlock
- Size:
- Venting to
  - Stack
  - Scrubber
  - Other
- Flame arrestors
- Nitrogen purged vents

4.4 Instrumentation
- Nitrogen padding pressure
- Temperature control
- Pressure control
- Level indicator
- Alarm settings:
  - Temperature
  - Pressure
  - Level
- Are controls / indicators and alarms independent?

4.5 Monitoring of storage
- Temperature
- Pressure
- Level

5. Storage tank to process

Precaution to prevent plant streams contaminating storage vessels.

6. Procedures

There should be written procedures available for the following:

- Identification of the product prior to unloading
- Unloading EO
- Testing, inspection and maintenance of equipment
- Emergency procedures including the rapid use, dilution or venting of the EO in the storage tank

7. Customer's comments

Annex 2
Guidance notes for ethylene oxide unloading / storage checklist

1. The unloading area

1.1

There should be sufficient space for easy vehicular access.

1.2

Unless it is connected to the unloading facilities, it should be possible for the vehicle to be removed from the unloading area in the case of an emergency. If it is connected to the unloading facilities, then the emergency arrangements should take account of the contents of the vehicle.

1.3

Barriers, warning notices (e.g. no access; no smoking) are required. Special consideration may need to be given to prevent shunting close to the unloading area.

1.4

There should be a manual water spray system. Ideally this should be a permanent installation over/ around the unloading area. Strategically placed fire hoses/monitors are acceptable.
The water system should be capable of knocking down vapour. The volume of water should be enough to dilute leakages one hundred fold before discharge to the sewer.

1.5

It is permissible for some materials (e.g. Propylene Oxide) to be off-loaded in the vicinity of EO. All unloading points must be clearly labelled. Any dry disconnect couplings used for EO should have the EO Selectivity Code.

1.6

Hoses or unloading arms should preferably be of stainless steel. They should be dedicated to EO, have suitable gaskets (spiral wound graphite or equivalent) and stored in such a way so as to prevent contamination.

1.7

The earthing point should have been checked on a regular basis.

2. The unloading

2.1.

The customer's operator must be present during off-loading.

2.2

The relevant parts of the CEFIC General Instructions for EO Drivers should represent the minimum requirements for training. The operator should be tested on this.

2.3

There should be at least sufficient trained deputies to provide cover for illness and holidays.

2.4

The test pressure of the loading arm should not be less than 1.5 times the maximum working pressure (according to standard regulations for pipes the test pressure is 1.3 times the maximum working pressure). The frequency of testing is recommended as at least every 12 months.

2.5

Air breathing sets with eye coverage. Protective suits, boots and gloves of suitable material (butyl rubber has been found to give the best degree of protection. Neoprene or natural rubber may also be considered for protective clothing, but may not remain vapour-tight, particularly after continued use. PVC offers only very limited resistance).
A safety shower and eye fountain should be sited adjacent to the unloading area.

2.6

During storage and unloading, a nitrogen pressure should be maintained within the non-explosive area as indicated in the graph of Appendix 5, Annex 1.

2.7

Hoses must be purged with nitrogen and leak tested before commencing the discharge.

2.8

If unloading is by pump, a vapour return system can be used provided the gas phase is within specifications.

2.9

If a pump is used, the pump system must be designed to control any abnormal temperature rise in the pump. For example, there should be a temperature trip and alarm and a low flow trip and alarm to prevent heating or running dry (a re-cycle loop is not essential for an off-loading pump).
A water sprinkler (manual or automatic coupled to a gas detector) should be provided for pumps.
A method for identifying seal leakages should be in operation.
Sealed pump design requires specific attention.

3. Nitrogen

Nitrogen is a potential source of contamination and the purity of the nitrogen must be maintained.

3.1

The nitrogen should preferably be supplied by a separate and independent dedicated supply system. The EO nitrogen supply system must not be shared with supplies to amines, acids or other catalysts for EO polymerisation.

Ideally the supplies for storage and the plant should be taken from two completely independent sources. If this is not possible or the system is shared the integrity of the nitrogen supply system must be protected.
All nitrogen lines must be fitted with back flow protection. Nitrogen should be taken from a high-pressure supply, which is protected by:

- Double block and bleed systems activated by a low positive pressure difference across the valves.
- Knock out drums fitted with level gauges and a high level alarm, or independent low pressure alarm with shut off valve.

4. The storage tank

Some of this section falls outside the unloading safety checking procedure. However, the information is useful both from safety and quality viewpoints. It also provides information on the customer's competence and attitudes to safety.

4.1

Insulated refrigerated storage is preferred but uninsulated tanks with a water drench are acceptable particularly in colder climates.

4.2

Relief valves should be large enough to cope with fire engulfment. Polymer formation is possible in flame traps. If these are used, regular inspection should be included in the maintenance schedules.

4.3

Level alarms are advised but if they are absent, procedures must be present which prevent tanks overfilling.

4.4

The temperature and pressure of the storage tank should be monitored and alarmed regularly.

5. Storage tank to process

Back flow and contamination prevention is essential. Similar equipment to that used for maintaining the nitrogen integrity should be used (see Section 3 above).

Appendix 9 Assessment of ferry operators and associated terminal facilities

Contents

1. Introduction
2. Management systems
3. Terminal facilities
4. Ferry management / equipment
5. Emergency systems

1. Introduction

This checklist has been developed to assist ferry auditing and does not cover structural design details of the vessels. It should be used as a simple aid to ensure that all basic elements and procedures are in place to secure a safe passage and that all persons involved are aware of the nature and risk of the product being transported.
Whilst in most cases the haulier/railway company will suggest the use of a particular ferry route, the consignor involved should always determine whether the particular ferry / operator / mode of transport is suitable.
No rating system has been incorporated in the checklist.

The checklist assumes that the ferry operator has a licence to operate, is in possession of the necessary documents to operate a ferry under national and international legislation, and that the vessel has the required certificate of seaworthiness.

The checklist is designed for RO / RO ferries which are in general use.

In due course it is anticipated that a Cefic assessment scheme will be developed as part of the ICE initiative which will include ferry structural design.

2. Management systems

- Does the ferry management have a safety, health and environmental policy?
- Is it prominently displayed on the ship and understood?
- Is there a drug - and alcohol policy?
- If the ferry is subchartered are the safety standards in force at least of the same standard as on the company owned vessels?
- Are there recruitment and staffing policies/procedures?
- Does the ferry line comply to the SOLAS requirements?
- Is management aware of the nature and hazards of the product (Safety Data Sheets), and actions to be taken in the event of an emergency?
- Does the ferry comply with the requirements regarding numbers of passengers carried?
- Is the ferry company ISO certified?
- Is there sufficient competence in marine engineering issues to assure the integrity of the ferry?

3. Terminal facilities/ systems

- Is the terminal/ferry interface managed effectively?
- Is the terminal located in a populated area?
- Is there a good road/rail infrastructure?
- Do the rail/road access routes pass through local city centres?
- Is sufficient supervised space available for safe parking of tankcars, tank containers and railtank cars with hazardous goods?
- Is there sufficient space and appropriate facilities to deal with emergencies?
- (e.g. firefighting, or in case of leakage transferring to other tankcars)
- Can hazardous goods road tankers, tank containers and rail tankcars easily evacuate the parking area in case of fire?
- Is a permit necessary from the terminal operator to enter the port area with hazardous goods?
- Is the access to the terminal area controlled by a security system?
- Is there sufficient fire fighting capability available either on the terminal or nearby to respond effectively?
- Is hazardous goods parking segregated from the parking for passenger, cars, coaches, etc?
- Are personnel trained in handling/exposure to chemicals, and actions to be taken in the event of emergency?
- Are appropriate emergency exercises carried out on a regular basis?

4. Ferry management / equipment

- Is the general appearance of the ferry externally sound and well cared for?
- Is the external plating heavily corroded and/or buckled?
- Are the hazardous goods vehicles correctly stowed with sufficient supporting chains to prevent movement?
- Does the place of stowage comply with the regulations? (Weather deck , sufficient ventilation, etc)
- Does the exposed weather deck have a sufficient high bulwark (at least 3 to 4 m high)?
- Are hazardous goods road tankers, tank containers and rail tank cars protected from adverse weather conditions (for instance not stowed right at the bow area where damage may be caused by large waves)?
- Is the principle of “last in - first out” applied for very hazardous goods allowing minimum exposure to damage during loading/unloading traffic movements and rapid exit in the event of emergency?
- Are smoking regulations in areas with hazardous cargoes enforced?
- Are systems in place to ensure that bow and/or stern doors are closed and sealed prior to departure?
- Is the condition of above seals and securing devices regularly checked?
- Are mandatory procedures strictly adhered to or do the masters have freedom of interpretation?

5. Ferry emergency systems

- Are the emergency procedures for passengers prominently displayed on the ship?
- Are the evacuation signs clear and visible also in case of power failure?
- Has the fire system (pumps, emergency pumps and emergency generators been tested frequently (logbook)?
- Is the fire fighting party on board conversant with the nature and precautions for the product in case of fire (chemical fire fighting course, Safety Data Sheets, Hazard identification number, UN number and Hazardous labelling)?
- Do ships crew carry out frequent fire/emergency drills (check logbook)?
- Does the emergency equipment include gas measurement, chemical suits and has the ships fire fighting personnel regularly trained in use of those items? (check status of equipment and experience in operation)
- Ask the crew to open some deck fire hydrants. Do they open easily?
- Does the captain have all the required information directly available regarding the nature and safety precautions relevant to the product?
- Is there an emergency system in place(24 hours) which can advise the captain and provide level - 1 response?
- Does the main office have duty personnel with access to a hazardous goods database available 24 hours?
- Are duty personnel trained and conversant with hazardous goods and do they have immediate access to hazard information? (Ask for a demonstration)
- Are there equipment/procedures in place to establish radio/telephone contact to and from the ship when it is at sea?

Appendix 10 Sector Group Member companies

COMPANY	COUNTRY
AKZO NOBEL	Netherlands
BASF	Germany
CLARIANT	Switzerland
DOW EUROPE	Switzerland
INEOS	Switzerland
MEGLOBAL	Switzerland
SABIC	Netherlands
SASOL	Germany
IQA	Spain
SHELL CHEMICALS	United Kingdom

Notice

“The information, specifications, procedures, methods and recommendations herein are presented in good faith, are believed to be accurate and reliable, but may well be incomplete and/or not applicable to all conditions or situations that may exist or occur. No representation, guarantee or warranty is made as to the accuracy, reliability or completeness of said information, specifications, procedures, methods and recommendations or that the application or use of any of the same will avoid hazards, accidents, losses, damages or injury of any kind to persons or property or that the same will not infringe patents of others or give desired results. Readers are cautioned to satisfy themselves as to the suitability of said information, specifications, procedures, methods and recommendations for the purposes intended prior to use”.