



CODE OF PRACTICE 46
THE STORAGE OF CRYOGENIC
FLAMMABLE FLUIDS
2016

British Compressed Gases Association

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THE STORAGE OF

CRYOGENIC FLAMMABLE FLUIDS

2016

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PREFACE

The British Compressed Gases Association (BCGA) was established in 1971, formed out of the British Acetylene Association, which existed since 1901. BCGA members include gas producers, suppliers of gas handling equipment and users operating in the compressed gas field.

The main objectives of the Association are to further technology, to enhance safe practice, and to prioritise environmental protection in the supply and use of industrial, food and medical gases, and we produce a host of publications to this end. BCGA also provides advice and makes representations on behalf of its Members to regulatory bodies, including the UK Government.

Policy is determined by a Council elected from Member Companies, with detailed technical studies being undertaken by a Technical Committee and its specialist Sub-Committees appointed for this purpose.

BCGA makes strenuous efforts to ensure the accuracy and current relevance of its publications, which are intended for use by technically competent persons. However this does not remove the need for technical and managerial judgement in practical situations. Nor do they confer any immunity or exemption from relevant legal requirements, including by-laws.

For the assistance of users, references are given, either in the text or Appendices, to publications such as British, European and International Standards and Codes of Practice, and current legislation that may be applicable but no representation or warranty can be given that these references are complete or current.

BCGA publications are reviewed, and revised if necessary, at five-yearly intervals, or sooner where the need is recognised. Readers are advised to check the Association's website to ensure that the copy in their possession is the current version.

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* Throughout this publication the numbers in brackets refer to references in Section 10. Documents referenced are the edition current at the time of publication, unless otherwise stated

TERMINOLOGY AND DEFINITIONS

System
Relevant fluid
Danger
Examination

User
Protective
Device
Owner

These terms are defined in the Pressure Systems Safety Regulations (9).

Access apron

Indicates an area between the tank or fill point and a tanker where the process operating controls on both tank and tanker are accessible to the operator during filling/discharging.

Competent person

The competent person should have such practical and theoretical knowledge and actual experience of the type of plant which he has to examine as will enable him to detect defects or weaknesses, which it is the purpose of the examination to discover, and to assess their importance in relation to the strength and function of the plant. Equivalent levels of knowledge and experience are also required for competent persons engaged in the writing or certifying of Written Schemes of Examination.

Cryogenic flammable fluid

For the purpose of this document a cryogenic fluid is deemed to be below $-150\text{ }^{\circ}\text{C}$. It includes liquid hydrogen, liquid natural gas, liquid methane, liquid bio-methane, liquid ethylene (ethene) and liquid ethane.

NOTE: It is accepted that liquid ethylene (ethene) and liquid ethane are above $-150\text{ }^{\circ}\text{C}$.

Flammable gas

A gas or gas mixture having a flammable range with air at $20\text{ }^{\circ}\text{C}$ at a standard pressure of 101.3 kPa.

Liquid transfer area

Indicates an area adjacent to the tank or fill point which surrounds the tanker, when the latter is in the filling/discharging position, and which includes the access apron.

Liquefied natural gas

For the purpose of this code of practice liquefied natural gas (LNG) is defined as liquefied upgraded methane rich gas such as liquefied bio-gas, liquefied bio-methane, land fill gas and coal bed gas.

May

Indicates an option available to the user of this Code of Practice.

Outer jacket

The insulation container.

Shall	Indicates a mandatory requirement for compliance with this Code of Practice and may also indicate a mandatory requirement within UK law.
Should	Indicates a preferred requirement but is not mandatory for compliance with this Code of Practice.
Tank	Indicates an assembly, complete with a piping system, of an inner vessel and an outer jacket to contain insulation. The insulation space will normally be subject to a vacuum.
Vessel	Indicates a pressure vessel, which may or may not be insulated.

CODE OF PRACTICE 46

THE STORAGE OF CRYOGENIC FLAMMABLE FLUIDS

1. INTRODUCTION

The objective of the British Compressed Gases Association (BCGA) Code of Practice is to make reference where applicable to UK legislation and international standards where these apply to cryogenic flammable fluid systems and to take into account the specific practices of the UK industrial gas companies particularly in relation to the minimum recommended separation distances.

This document has been produced due to the specific hazards associated with cryogenic flammable fluids and compliance with additional regulations and standards over and above that required for cryogenic inert gases. This Code of Practice takes account of the European Industrial Gases Association (EIGA) Document 6 (56), *Safety in storage, handling and distribution of liquid hydrogen*.

The storage of cryogenic flammable fluids in the liquid state under pressure at users' premises not only provides an efficient way of storing gas, but improves safety when used in conjunction with a distribution system, by eliminating the need for cylinder handling, and is a more efficient and safer method of handling larger quantities. However, the particular properties of cryogenic flammable fluids necessitate certain precautions to be taken and certain rules to be followed.

The installation may have other cryogenic fluids associated with the installation. Refer to BCGA Code of Practice (CP) 36 (76), *Cryogenic liquid storage at users' premises*.

BCGA has also published Leaflet 12 (85), *Liquid gas storage tanks: Your responsibilities*, which is a simple user guide that advises users and owners of liquid gas storage tanks on their legal responsibilities and duty of care to ensure that the equipment is maintained and operated safely.

This document is intended for the guidance of those persons directly associated with the design, installation, commissioning and operation of cryogenic flammable liquid storage installations. It does not claim to cover the subject completely but gives advice and should be used with sound engineering judgment.

This document is not a Design Code. The user of this code of practice shall make reference where applicable to UK legislation and internationally recognised Standards where these apply and to take into account the specific practices of the UK industrial gases companies.

It is pointed out that this code of practice, along with the range of other BCGA publications, represent the BCGA's view of minimum requirements for safe practice.

All new storage installations shall comply with this code of practice.

The BCGA acknowledges the support of the Health and Safety Executive (HSE), the UKLPG and the Institution of Gas Engineers and Managers (IGEM) in producing this code of practice.

2. SCOPE

A flammable cryogenic fluid storage system installation is defined for the purposes of this Code of Practice as the installed static liquid storage tank(s), mobile tank(s) used in a static location and installations that are supplied via a road tanker, together with the control equipment for the tank and its associated safety systems, the storage location, access apron and the liquid transfer area.

For the purposes of this Code of Practice the demarcation points are located between the flammable cryogenic fluid storage system, (comprising of the liquid storage tank together with the control equipment and safety devices, vaporising equipment, the storage location, access apron and the liquid transfer area) and the systems it services and the plant or equipment from which it is filled.

This document applies to static, vacuum insulated, tanks with an individual water capacity up to 125,000 litres operating at pressures greater than 0.5 bar above atmospheric pressure designed to store cryogenic flammable liquids. This document may also be used as base guidance for installations in excess of 125,000 litres including multiple tanks operating as a single tank.

For the purpose of this document transportable cryogenic liquid tanks (such as 'liquid cylinders', cryogenic receptacles, containerised tanks, dewars and road tankers) are included where they are left in situ and used as a method of storing and supplying product. This code does not cover the construction or transportation of such tanks or trailers as these are covered by specific Regulations and Codes for transportable vessels.

Specifically excluded from this Code of Practice are:

- Liquefied Petroleum Gas (LPG) – Refer to UKLPG publications, for example, UKLPG Code of Practice 1 (86), *Bulk LPG storage at fixed installations*. The specification for LPG is detailed in BS 4250 (38), *Specification for commercial butane and commercial propane*.
- The storage of cryogenic flammable fluids for applications covered by the Gas Safety (Installation and Use) Regulations 1998 (7) such as the supply of domestic and non-domestic systems.
- The bulk storage of gaseous hydrogen. Refer to BCGA CP 33 (75), *The bulk storage of gaseous hydrogen at users' premises*.
- The bulk storage of cryogenic inert and oxidant gases. Refer to BCGA CP 36 (76).
- The in-service requirements of pressure equipment. Refer to BCGA CP 39 (77), *In-service requirements of pressure equipment (gas storage and gas distribution systems)*.
- Vehicle refuelling. Refer to BCGA CP 41 (78), *The design, construction, maintenance and operation of filling stations dispensing gaseous fuels*.
- The storage of compressed gas cylinders. Refer to BCGA CP 44 (79), *The storage of gas cylinders*.

- Odourising systems.
- Liquefied flammable gases, for example, Ammonia.

3. GENERAL DESIGN AND SAFETY CONSIDERATIONS

3.1 General

The storage system design and installation shall comply with:

- The Pressure Equipment Regulations (8);
- The Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) (12);
- The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations (3);
- The Pressure Systems Safety Regulations (PSSR) (9); and
- The Provision and Use of Work Equipment Regulations (PUWER) (6).

Depending on the quantity of cryogenic flammable fluid being stored compliance may be required with, for example, the Control of Major Accident Hazards Regulations (COMAH) (14) and the Dangerous Substances (Notification and Marking of Sites) Regulations (2). In addition approval may be required from the Hazardous Substances Authority under the Planning (Hazardous Substances) Act (1). Refer to Section 4.1.

All cryogenic flammable fluids are classified as flammable and are asphyxiant.

The following documents should be taken into consideration:

- BCGA Guidance Note (GN) 11 (80), *Reduced oxygen atmospheres. The management of risk associated with reduced oxygen atmospheres resulting from the use of gases in the workplace.*
- BCGA GN 13 (81), *DSEAR Risk Assessment.*
- HSE L122 (24), *Safety of pressure systems. Pressure Systems Safety Regulations 2000. Approved Code of Practice.*
- HSE L138 (25), *Dangerous substances and explosive atmospheres. DSEAR 2002. Approved Code of Practice and guidance.*
- HSE HSR29 (19), *Notification and marking of sites. The Dangerous Substances (Notification and Marking of Sites) Regulations 1990. Guidance on Regulations.*

3.2 Properties of cryogenic flammable fluids

The physical properties of typical cryogenic flammable fluids, are given in Table 1:

	Hydrogen	Methane	Ethane	Ethylene / Ethene
Chemical symbol	H ₂	CH ₄	C ₂ H ₆	C ₂ H ₄
Molecular weight	2.016	16	30	28
Normal boiling point °C (K)	-253 (20.4)	-161 (112.2)	-89 (184.2)	-104 (169.2)
Freezing temperature °C (K)	-259 (14)	-183 (90.2)	-183 (90.2)	-169 (104.2)
Critical temperature °C (K)	-240 (33.2)	-82 (191.2)	+32 (305)	+10 (283)
Critical pressure, bar	13	46	48.7	50.4
Volume (m ³) of gas at 1 bar, 15 °C released from 1 litre of liquid boiling at 1 bar.	0.844	0.613	0.430	0.482
Density of saturated liquid at 1 bar (kg/m ³)	70.85	423	544	568
Gas density relative to dry air (reference conditions 1 bar, 15 °C)	0.07	0.56	1.05	0.97
Latent heat of vaporisation at 1 bar (cooling potential of phase change) kJ/kg	445.7	510.6	488.5	482.9
Air liquefaction hazard	Yes	No	No	No
Flammable limits in air (vol. %) Refer to Section 3.2.4	4 to 75	5 to 15	3 to 12.4	2.7 to 36
Spontaneous ignition temperature in air °C (K) Refer to Section 3.2.1	400 (673)	540 (813)	510 (783)	450 (723)
Minimum ignition energy (mJ) Refer to Section 3.2.3	0.02	0.28	0.24	0.085
Flame temperature °C (K)	2373 (2646)	1880 (2153)	1895 (2168)	1975 (2248)
Limiting oxygen index (vol.%) Refer to Section 3.2.5	5	11.5	11.0	11.5

Table 1: Properties of typical cryogenic flammable fluids

The specification for LNG is detailed in BS EN 1160 (34), *Installations and equipment for liquefied natural gas. General characteristics of liquefied natural gas.*

NOTE: The individual characteristics of LNG can vary depending on its source. Reference should be made to the supplier's data sheets.

The ignition and burning characteristics of cryogenic flammable fluids are:

3.2.1 Spontaneous ignition temperature

Hydrogen, methane, ethane and ethylene have spontaneous ignition temperatures as detailed in Table 1. The spontaneous ignition temperature is the temperature above which the gas is likely to spontaneously ignite in air. These values depend on the purity of the gases, the concentration of the gas in air (its dilution in air), and to some extent on the ambient conditions.

3.2.2 Laminar burning velocity and significance of confinement

The laminar burning velocities of methane and ethane are low compared with other hydrocarbons (less than 0.5 ms^{-1}). However, ethylene has almost twice the velocity of methane. The burning velocity is an indication of the tendency of a flame to 'run up' to deflagration. It has been shown that, given the appropriate degree of confinement and congestion, all these fuels can 'run up' to a deflagration. Detonation is unlikely, although not impossible.

3.2.3 Minimum ignition energy

Minimum ignition energy is an indication of the amount of energy required to start an ignition. Although the auto-ignition temperature of hydrogen is higher than those for most hydrocarbons, hydrogen's lower ignition energy makes the ignition of hydrogen-air mixtures more likely. Typical hydrogen, methane, ethylene and ethane minimum values are detailed in Table 1.

3.2.4 Flammable range

The flammable range is the volume percentage of gas in the air in which combustion can occur. Outside of this range the gas will not combust. Typical hydrogen, methane, ethylene and ethane minimum values are detailed in Table 1.

3.2.5 Limiting oxygen index

The limiting oxygen index is the least amount of oxygen required to support combustion. Typical hydrogen, methane, ethylene and ethane minimum values are detailed in Table 1.

3.2.6 Decomposition

Ethylene or an ethylene / diatomic gas mixture can undergo thermal decomposition reactions at elevated pressures in certain circumstances. Care must be taken to avoid the rapid pressurisation of systems over a large pressure range, and also to avoid 'hot spots' on equipment such as pumps, compressors, etc., which may initiate decomposition.

Additional information on the properties and effects of hydrogen are available in EIGA Document 6 (56). Additional information on the properties of methane, ethylene and ethane is available in the British Cryoengineering Society, *Cryogenic Safety Manual* (87) and the *Cryogenics Fluid Databook* (88).

3.3 Hazards and precautions

The properties of cryogenic flammable fluids justify the following special precautions:

3.3.1 Flammable atmospheres

Flammable gases in certain concentrations with air or oxygen form flammable mixtures; care must therefore be taken to prevent uncontrolled releases to atmosphere. Due to the low temperatures at which the liquids are stored, any release is initially heavier than air and will tend to fall to ground level and spread until the gas temperature rises to a point at which the gases are lighter than air or neutrally buoyant. There will be a significant increase in volume as the liquid changes state into a gas.

Flammable atmospheres are likely to occur at vent outlets. As gas flows through the pipelines and vents there is the potential for static electricity to be produced. Appropriate earthing and bonding is required, refer to Section 3.7.

NOTE: The composition of natural gases can vary depending on the source of the gas, this may affect its flammability limits.

3.3.2 The effects of a reduced oxygen atmosphere on personnel

The atmosphere normally contains approximately 21 % by volume of oxygen. If the oxygen concentration in the atmosphere decreases there is an increase in the degree of hazard and potentially an increased risk of asphyxiation. Flammable gases will act as asphyxiants by displacing the oxygen from the atmosphere.

The hazards from oxygen deficiency are further explained in Appendix 1. For additional advice refer to BCGA GN 11 (80) and EIGA Document 44 (62), *Hazards of inert gases and oxygen depletion*.

Good ventilation shall always be provided in places where liquid cryogenic flammable fluids are stored, used and / or transferred.

A space containing a reduced oxygen atmosphere meets the criteria of a confined space within the meaning of the Confined Spaces Regulations (5). These require that employers should carry out an adequate risk assessment and put in place appropriate control measures to protect those accessing or working in the area. For additional information refer to HSE L101 (23), *Safe work in confined spaces. Confined Spaces Regulations 1997. Approved Code of Practice, Regulations and guidance*.

3.3.3 Liquefaction of air

Ambient air may condense on uninsulated pipes, vaporisers and vessels containing liquid hydrogen, causing local oxygen enrichment of the atmosphere. Pipework and vessel insulating materials should be chosen bearing in mind that oxygen enrichment may occur. Increased oxygen levels can contribute towards the fire hazard.

Consideration shall be given to the design and layout of equipment, particularly vents, to minimise the risk of oxygen enriched air mixing with a flammable gas atmosphere.

WARNING: Where liquid air may be present the use of oils, grease and organic materials may significantly increase the likelihood of a fire or explosion hazard from localised oxygen enrichment.

3.3.4 Cryogenic burns

Severe damage to the skin may be caused by contact with cryogenic liquids, their cold gases or with uninsulated pipes or receptacles containing liquid cryogenic gases. As appropriate, equipment should either have suitable permanent insulation fitted or other practical alternative measures should be taken to prevent contact with the skin. Otherwise Personal Protective Equipment (PPE) shall be worn in accordance with the PPE Assessment, refer to Section 3.3.7. For advice on the treatment of cryogenic burns refer to Appendix 2.

3.3.5 Effects of cold on personnel

Prolonged breathing of extremely cold atmospheres, for example cold air around ambient vaporisers, may damage the lungs.

Severe or prolonged exposure to cold vapours and gases can cause frostbite.

Low environmental temperatures can cause hypothermia. Susceptibility to hypothermia depends on the length of exposure, the temperature and the individual. Older persons are more likely to be affected. Appropriate clothing is required to protect from the cold temperature. Clothing is to be provided as determined in the PPE Assessment, refer to Section 3.3.7.

3.3.6 Perlite

Perlite is commonly used for the insulation of storage tanks. Perlite is a natural volcanic mineral that can be expanded by heating to form very lightweight, porous, odourless, non-flammable, non-toxic silicate powder. Being lightweight it becomes airborne very easily. A perlite product can contain crystalline silica, which is considered to be a nuisance dust. However, the nature of the material and the large quantities involved require the use of specific operating, handling, and safety procedures.

If perlite enters the eyes or respiratory tract, it can cause serious irritation. An uncontrolled release, such as from a tank, can result in large quantities of perlite being expelled which may result in personnel becoming engulfed and trapped, leading to suffocation. An emergency plan should be prepared to cover an uncontrolled perlite release, refer to Section 9.1. For further information refer to EIGA Document 146 (68), *Perlite management*.

3.3.7 Personal protective equipment

Personal Protective Equipment (PPE) is to be provided as required by the Personal Protective Equipment Regulations (10). PPE may only be considered as a control to achieve an acceptable level of residual risk after other levels of control have been addressed. A risk assessment will determine the requirement for the use of hazard controls, including PPE. Where PPE is required a PPE Assessment is to be carried out. Due regard is to be given to the requirements of the Control of Substances Hazardous to Health (COSHH) Regulations (11), any relevant equipment publications, manufacturers information and the product Safety Data Sheet. The PPE shall be selected for a particular task and location and must be appropriate and chosen to effectively reduce the overall risk. Thus there are different PPE requirements for differing products, different tasks and possibly different personnel.

HSE L25 (20), *Personal Protective Equipment at Work*, provides guidance on the Personal Protective Equipment Regulations (10). EIGA Document 136 (67), *Selection of personal protective equipment*, provides guidance for selecting and using PPE at work.

To help prevent ignition of flammable cryogenic gases PPE should be anti-static, non-flammable and flame retardant.

For personnel entering the storage area the typical minimum PPE requirements include eye protection and clothing that is anti-static and flame retardant. Personnel maintaining, operating or filling the storage system may require additional PPE such as gloves, anti-static and safety footwear, hard hats, warm under clothes, ear defenders, and breathing apparatus.

Where there is the possibility of a flammable or asphyxiating atmosphere, the use of gas monitors should be considered.

All the safety aspects of handling cryogenic liquid cannot be covered adequately in this Code of Practice. For further information refer to the British Cryoengineering Society, *Cryogenic Safety Manual* (87).

3.4 Service requirements

3.4.1 Material compatibility

All materials used shall be compatible with the product being stored, at the required temperature and pressure conditions. Particular attention shall be given to elastomers and soft sealing components.

Polytetrafluoroethylene (PTFE) is the most widely used plastic material for sealing purposes in cryogenic service but other reinforced plastics are also used.

Materials such as Polychlorotrifluoroethylene (PCTFE) are used as a protective layer to minimise wear.

The selection and use of materials shall be carefully considered in the design of the installation to avoid secondary failure in the event of external fire.

3.4.2 Embrittlement of materials

Many materials, such as some carbon steels and plastics, are brittle at very low temperatures and the use of an appropriate material for the service conditions prevailing is essential.

Nickel steel, austenitic stainless steels, copper and its alloys and aluminium alloys are metals which are generally suitable for cryogenic liquid service. Refer to the relevant design code and material standards.

Under certain conditions pressurised pure hydrogen can cause ambient temperature embrittlement of welded carbon steel fabrications. The selection of materials for equipment and components needs careful consideration. Refer to EIGA Document 15 (58), *Gaseous hydrogen stations*, for additional information.

For further information on materials see BS 5429 (41), *Code of Practice for safe operation of small-scale storage facilities for cryogenic liquids*.

3.4.3 Cleaning

Before putting equipment into service, either for the first time or following maintenance, all storage systems shall be cleaned to ensure the product is stored and delivered at the correct specification, there are no loose contaminants in the system which could impede the correct operation of system components and that there is no long term degradation of the storage system.

It is strongly recommended that all surfaces which may come into contact with the product:

- Are dry and free from water contamination;
- Are free from any loose or virtually loose constituents, such as slag, rust, weld residues and blasting materials;
- Have all cleaning and degreasing agents removed;
- Are entirely free from other materials incompatible with the product, refer to Section 3.4.1.

Where the user or installer is unsure of the cleaning process to be used specialist cleaning companies should be employed. These companies should also take the responsibility for the supply of appropriately registered chemicals and the safe and legal disposal of used cleaning agents.

Advice on the cleanliness of cryogenic vessels is available in BS EN 12300 (46), *Cryogenic vessels. Cleanliness for cryogenic service*.

3.5 Fire precautions

The storage of cryogenic flammable fluids shall be included in the site Fire Safety Management Plan. Refer to Section 4.2.

All cryogenic flammable fluids are within the scope of DSEAR (12) and require a risk assessment in accordance with these regulations. Refer to Section 4.9.6. Guidance on carrying out a DSEAR (12) risk assessment is available in BCGA GN 13 (79).

NOTE: In order to be compliant with European ATEX Workplace Directive 99/92/EC (18) an explosion protection document (EPD) is required. The EPD has to be kept up to date throughout the life cycle of the tank, associated plant and equipment. Notably DSEAR (12) makes no mention of the term EPD but the requirement for up to date information is very much a part of the UK regulation and an EPD certainly fits the need.

Good housekeeping is necessary to prevent contamination by loose debris or combustibles. Other flammable substances, combustible materials and oxidising substances shall not be stored or allowed to accumulate in the vicinity of cryogenic liquid installations. Appropriate separation distances shall be applied, refer to Section 4.4.

3.6 Maintenance

Before maintenance is carried out on the installation, a written Permit to Work for the particular type of work (cold work, hot work, entry of vessel, electrical work, etc.) shall be issued by an authorised person to the individual(s) carrying out the work. All maintenance activities will require a risk assessment to determine if the system needs to be purged with inert gas, especially where the use of heat or spark producing tools is necessary.

HSE HSG 250 (30), *Guidance on permit-to-work systems. A guide for the petroleum, chemical and allied industries*, and EIGA Document 40 (61), *Work permit systems*, provide recommendations on how to plan and execute potentially hazardous jobs in a safe manner.

3.7 Ignition sources

Smoking and naked flames shall be prohibited within the minimum recommended separation distances specified in Section 4.4. Notices shall be displayed, refer to Section 5.4.

Electrostatic charges can build up, for example, as a result of friction in pipes or by the break-up of liquid hydrogen to droplet size. This can cause ignition where gas is venting to atmosphere. Routine inspection to ensure the integrity of electrical earthing and bonding systems on plant equipment is essential. Refer to Section 4.9.7. Whenever maintenance work has been carried out, the electrical bonding should be checked before re-commissioning.

Electrostatic charges can build up from clothing. The correct PPE should be worn at all times, refer to Section 3.3.7

Electrical equipment can be a source of ignition. All electrical equipment shall meet the requirements of Section 4.9.6.

Mechanical equipment should also be considered as it can be a source of heat, and may produce sparks. In particular, where the installation contains aluminium in a location where there is also a risk of ferrous materials corroding there is the potential for thermite reactions to occur.

3.8 Venting

All of the cryogenic flammable fluids within the scope of this code are stored under pressure. As such they are fitted with over pressure protection devices to release excess pressure under normal operating conditions and in emergency situations such as fire. For filling and maintenance purposes manually operated valves are fitted to release pressure. When these devices operate any product that is subsequently vented shall be dispersed safely to reduce the risk of accumulation, ignition, or impingement on personnel, equipment and buildings. This is achieved by the use of a vent system where the product is released via a remote vent stack.

Refer to Section 4.6 for detail on the design of vent systems.

3.9 Methods of isolation

Each tank shall have an isolation valve fitted. Isolation valves should be located as close as practicable to the storage system and within a secure area. Where numerous

storage vessels are used, consideration should be given to separating these into isolatable sub-groups.

HSE provide guidance on how to isolate plant and equipment safely, and how to reduce the risk of releasing hazardous substances during intrusive activities such as maintenance and sampling operations in document HSG 253 (31), *The safe isolation of plant and equipment*.

3.10 Emergency shut-down systems

An emergency shut-down (ESD) system shall be incorporated into the design to isolate the liquid supply. The means of isolation should be close to the tank and of a fail-safe design and remote activation should be considered. For details on activation refer to Section 4.7.7 and for the means of isolation refer to Section 4.9.5.

For further information refer to BS EN 13645 (49), *Installations and equipment for liquefied natural gas. Design of onshore installations with a storage capacity between 5 t and 200 t*.

NOTE: If the installation is part of a vehicle fuelling station refer to documents such as BCGA CP 41 (78), IGEM/UP/20 (89), *Compressed natural gas fuelling stations*, and the Blue Book (90), *Design, construction, modification, maintenance and decommissioning of filling stations*.

4. LAYOUT AND PLANT DESIGN REQUIREMENTS

4.1 General

The installation shall be sited to minimise risk to personnel, the local population, other local hazards and property. The installation should always be located outside in the open air in a well-ventilated position. Refer to Section 4.5 for detailed considerations on a suitable location.

A major concern associated with the storage of all cryogenic flammable fluids is the risk of fire and explosion. The probability of a fire and explosion hazard is reduced by the provision of good design and layout, as well as appropriate operating procedures. Refer to Section 4.2.

Consideration should also be given to the likelihood of seismic events in the area from natural or manmade activities (such as where explosives are used, for example in quarries, mining, military etc.). Where the likelihood exists the site shall be protected against physical damage, particularly from impact or vibration.

An installation may, because of its size or strategic location, come within the scope of specific planning controls. Approval may be required for the installation from the local planning authority, the fire authorities and the HSE. These requirements should be resolved with the owners of the premises where the installation is planned.

Hazardous substances consent will be required from the relevant Hazardous Substances Authority (HSA) for the presence of substances above the controlled quantities shown in Table 2 in accordance with the Planning (Hazardous Substances) Regulations (15), (and equivalent legislation in Scotland and Wales).

	Planning (Hazardous Substances) Regulations	Control of Major Accident Hazards Regulations (COMAH)	
		Lower tier	Upper tier
Hydrogen	2 tonnes	5 tonnes	50 tonnes
LNG	15 tonnes	50 tonnes	200 tonnes
Liquid Methane / Bio-methane	15 tonnes	50 tonnes	200 tonnes
Ethylene / Ethene	15 tonnes	50 tonnes	200 tonnes
Ethane	15 tonnes	50 tonnes	200 tonnes

Table 2: Thresholds for the different cryogenic flammable fluids

If the site also stores other in scope hazardous substances lower thresholds may apply and if the site already has hazardous substances consent for other substances it may need to be revised.

Under the COMAH Regulations (14) there are specific duties to notify the Competent Authority of the anticipated presence of dangerous substances above the qualifying quantities set out in Table 2 (under the heading COMAH). There are also specific duties on operators under these regulations to take all necessary measures to prevent major accidents and limit their consequences to persons and the environment. Additional duties will apply to operators of Upper Tier sites to prepare safety reports and on-site emergency plans and to assist with the preparation of off-site emergency plans.

Under both hazardous substances consents and COMAH (14) legislation, sites storing less than the threshold quantities shown in Table 2 should give careful consideration to the total quantity of dangerous substances on site in accordance with the relevant addition rules.

Further to these, the Dangerous Substances (Notification and Marking of Sites) Regulations (2) require notification to the authorities where a total quantity of hazardous products of 25 tonnes or more are stored, specific exemptions apply.

Due consideration should be given to human factors in the design and layout of plant and equipment, following basic ergonomic principles. Refer to EIGA Safety Information 12 (72), *Task – Human factors in design*.

The location chosen for the installation shall be acceptable to the land owner, the installer, the gas supplier and the user (duty holder) for the storage of cryogenic flammable liquids.

4.2 Fire risk management

A responsible person shall carry out a Fire Safety Risk Assessment on all storage sites, the findings from which are to be incorporated into the Site Fire Safety Management Plan that is to be implemented and maintained. As necessary, advice should be sought from the local fire authority. Each site should keep a record of the location of its hazardous store(s), this is to be made available to the emergency services in the event of an incident. Refer to The Regulatory Reform (Fire Safety) Order (13).

Fire-fighting facilities as identified in the Site Fire Safety Management Plan shall be provided. Large quantities of water may need to be available, not only for fighting the fire but for keeping adjacent equipment cool and to prevent the fire spreading. Consideration is to be given to the volume and pressure of available water. Refer to BS 5306, Part 0 (40), *Fire protection installations and equipment on premises. Guide for selection of installed systems and other fire equipment*.

Suitable access for the emergency services personnel and vehicles, such as the Fire and Rescue Service and their equipment as well as any site emergency equipment, shall be provided.

Adequate means of giving alarm in the event of a fire shall be provided. These should be clearly marked and suitably located, including at all emergency exit points. For electrical requirements refer to Section 4.9.6.

Wherever practicable, the use of combustible materials should be avoided.

Appropriate fire precaution signs shall be displayed within all cryogenic flammable fluid storage areas. Refer to Section 5.4.

Appropriate emergency procedures shall be drawn up based on the Site Fire Safety Management Plan, these to include an evacuation plan covering all personnel likely to be on the site. For emergency procedures in the event of an incident, refer to Section 9.

To reduce the fire hazard to a minimum the area surrounding the storage site is to be kept clear. Long grass, weeds and any overhanging branches are to be removed. A space of 3 m around the storage area is to be kept clear of all vegetation, undergrowth and combustible material. In addition, the undergrowth is to be kept as short as possible for a total distance of 9 m around the storage area. Chemicals such as sodium chlorate and other oxidising agents which may cause a risk of fire shall not be used as a weed killer. Appropriate signs should be displayed.

Further information on managing the fire and explosion hazard of cryogenic flammable fluids is available in the British Cryoengineering Society, *Cryogenic Safety Manual* (87).

4.3 General security

The storage installation shall be secure and access shall be restricted to authorised personnel. This may be achieved by securing the site with a boundary fence with lockable gates or by fencing each and every storage installation. Dependant on the site security requirements both conditions may be required.

Suitable security arrangements shall take into account the classification of the gases and the quantities being stored. The security arrangements shall include appropriate physical and management security controls to prevent unauthorised access, theft, tampering, arson, vandalism and to effectively monitor the usage of gases, as well as any specific local considerations.

Where electronic security systems, for example, alarms, are installed, comply with the electrical requirements of Section 4.9.6.

Where there is vehicle access to and around the storage installation then appropriate protection of the installation from vehicle impact for example by barriers, bollards or kerbs shall be installed.

Where fencing is provided, access between the fence and the tank with its associated equipment will be required, for example, for maintenance as well as to allow free access and escape for personnel from inside the enclosure. The minimum clearance between the fence and the installation shall be 0.8 m.

For 'open' fences, the minimum recommended separation distances will apply regardless of the position of the fence, refer to Section 4.4.

The height of the fence shall be a minimum of 1.8 m.

Fencing should be constructed in such a way that it does not impede the ventilation around the installation. Readily combustible materials, such as timber, shall not be used for fencing.

Any gates should be outward opening and wide enough to provide for an easy access and exit of personnel. The main gate should have two wings, each at least 0.6 m wide. Gates shall be secured during normal operation.

An additional emergency exit should be installed where the size of fenced area or equipment location necessitates this. The emergency exit gate should have a minimum of one wing, at least 0.8 m wide. All emergency exits are to open in the direction of escape and are to be fitted with panic furniture of a type not requiring a key, card, or code to open. They are to provide an unobstructed means of escape and in operation are not to obstruct any other escape route. Ensure emergency exits are secure and cannot be opened from the external side of the store (whilst still allowing emergency escape from the inside of the store). These exits are to be properly identified by signage, and maintained in a serviceable condition at all times.

4.4 Minimum recommended separation distances

Minimum recommended separation distances are considered to give protection against risks involved, according to practical experience, in the normal operation of storage installations, covered by this Code of Practice. They are defined as the distance from the exposure or item to be protected to the nearest of the following:

- Any point on the storage system where in normal operation leakage or spillage can occur (for example, mechanical joints, including those on extended fill lines, relief valve vents, etc.); or

NOTE: These will be established during the DSEAR (12) Risk Assessment.

- the tank outer jacket; or
- the vaporiser (process or pressure building); or
- the fill connections.

Minimum recommended separation distances are intended to:

- Protect personnel from exposure to the product in the event of a release.
- Protect the installation from the effects of thermal radiation or jet flame impingement from fire hazards.
- Keep people remote from hazards such as extreme cold, venting gases, operating machinery, trip hazards etc.
- Protect people, occupied buildings and other equipment which could allow a fire to escalate from the effects of thermal radiation or jet flame impingement in the event of a fire.

The minimum recommended separation distances are given in Appendix 4. Where any DSEAR (12) zoned area is in excess of the minimum recommended separation distance then the greater distance shall apply.

Road tankers which are used as the storage tank on a full for empty exchange basis shall comply with the minimum recommended separation distances.

Minimum separation distances are not required to give full protection against every type of incident but should prevent small incidents from escalating, i.e. domino effects and should provide a level of protection while the emergency response and associated measures are initiated, for example, evacuation, arrival of the fire service, etc.

The minimum recommended separation distances given in this Code of Practice are based on experience and calculations of minor release. These distances correspond to well established practice and are derived from operational experience within Europe and the USA. They relate to over hundreds of thousands of tank years in service. The minimum recommended separation distances given are not intended to protect against catastrophic failure of the liquid storage vessel. Previous operating history, the protective devices fitted, material properties and the mode of vessel construction support this philosophy.

Consideration of all major accident hazards, including catastrophic vessel failure and full-bore rupture of the largest liquid pipework will have to be addressed by operators of sites subject to the COMAH regulations (14). In addition, consideration of all major accident hazards will be taken into account by the HSE in providing advice to local authorities in respect of sites that require hazardous substances consent.

Shorter distances may be used if a site specific risk assessment in line with EIGA methodology (using HSE fatality rates) indicates an acceptable level of risk. Refer to EIGA Document 75 (65), *Determination of safety distances*.

Where the required minimum recommended separation distances cannot be achieved, a permanent physical partition may be used. The separation distance may then be measured around the ends of the partition to the installation. Such partitions should be of at least 60 minutes' fire-resisting construction, imperforate and constructed of materials such as solid masonry or concrete. They should be not less than 2.5 metres high for cases other than diverting liquid spills. Refer to HSE L138 (25), and BS 476 (33), *Fire tests on building materials and structures*.

The distance between the installation and the exposure around the ends of the segregation walls should be equal to or greater than the minimum recommended separation distances given in Appendix 4.

Tanks shall have adequate distance between each other and any other tanks to allow free access and egress, for example, for fire-fighting, maintenance, cleaning etc. An adequate distance is, in the case of cylindrical tanks, half the diameter of the tanks; in all cases, including smaller tanks, it shall be a minimum of 1.5 m. Refer to Appendix 4.

Care must be taken to ensure that good ventilation is retained. It is recommended that walls should not be constructed on more than two sides of the installation. Where this is unavoidable a risk assessment shall be conducted.

The installation shall not be located beneath or near piping containing all classes of flammable and combustible liquids, piping containing other flammable gases, or piping containing oxidising materials.

The installation shall not be located directly beneath electric power cables. For electrical power cables operating at a voltage of less than 1 kV the tanks should be sited at least 1.5 m from a plane drawn vertically downwards from the power cables. Such power cables include telephone cables. For cables operating at a voltage of 1 kV or greater the distance should be increased to 10 m. Further advice and information may be obtained from the power cable operator, refer also to BS EN 50110, Part 1 (52) *Operation of electrical installations. General requirements*. These distances may need to be increased where the presence of the overhead line could constitute a danger to users of the facility or loading tankers and personnel. For additional advice refer to HSE Guidance Note GS 6 (27), *Avoiding danger from overhead power lines*.

4.5 Considerations for the location of the installation

The installation shall be sited to minimise risk to personnel, the local population, other local hazards and property. Consideration should be given to the location of any potentially hazardous processes in the vicinity, which could jeopardise the integrity of the storage installation. Physical separation of the storage installation from exposures or sources of hazard shall be enforced to minimise the consequences of incidents, with consideration to be given to hazards arising from both flammable atmospheres and heat flux following ignition.

Installations shall not be located where there is any restriction of the means of escape in an emergency.

The tank shall not be located on top of underground services, other storage vessels, tanks, chambers or voids. For additional advice refer to HSE HSG 47 (28), *Avoiding danger from underground services*.

Consideration shall be given for provision to divert any spillage away from, the tank, manholes, drains, gullies, etc.

Storage tanks shall not be located indoors.

Wherever possible the installation should always be located above ground, in an external location, in the open air, in a well-ventilated position with no roof. Adjacent buildings, structures and geographical features may adversely affect natural ventilation

and their effect should be taken into account. A well-ventilated position will prevent flammable gases accumulating to the point where they create an asphyxiant atmosphere or exceed their lower flammability limits in air. System design, preventative maintenance, as well as appropriate operating procedures reduce the risk of gas leakage. The location and the quantity and quality of ventilation will determine the level of gas accumulation for a given leak and vent rate. The major concern associated with the storage of all cryogenic flammable fluids is the risk of fire and explosion. Refer to Section 3.5 (DSEAR (12)), Section 4.1 (COMAH (14)) and Section 4.2 (Fire safety).

Areas which are enclosed on two or more sides are likely to have restricted ventilation and should be avoided. However, such a location is unavoidable, an assessment to confirm the adequacy of the ventilation available shall be conducted.

Additional requirements shall be considered for storage tanks located below ground level or within pits, ditches and other ground depressions. Further information on hydrogen storage is available in EIGA Document 171 (70), *Storage of hydrogen in systems located underground*.

Where there is a roof or a structure above associated equipment the design of the roof or structure shall prevent the accumulation of any lighter than air gases.

The installation shall be located so that it is readily accessible to delivery vehicles, to authorised personnel and to the emergency services. However, it shall be protected against physical damage, and access by unauthorised personnel. Storage installations should be situated where there is no risk of damage by passing vehicles. For details on general security requirements refer to Section 4.3.

Any modifications shall be carried out in accordance with the applicable design code and in consultation with the gas supplier.

When gas is not being withdrawn pressure within the tank will gradually increase to the point where the relief valve will lift. All relief valves shall be connected into the vent system and shall discharge via the vent stack. For the location and height of the vent stack, refer to Section 4.6.

4.5.1 Protection against lightning

Consideration should be given to providing lightning protection, refer to Section 4.9.7.

4.5.2 Installation level and slope

Storage tanks should be at the same level as the tanker parking area to enable the operator/driver to control the transfer operations, as well as to avoid any trip hazards.

Where liquid cryogenic storage tanks are required to be installed at an elevated level, they shall be supported by purpose designed structures which should withstand or be protected from damage by cryogenic liquid spillage.

The slope of the ground shall be such as to allow surface water run-off and to ensure liquid spills are directed to a safe place.

4.5.3 Vapour clouds

Consideration shall be given to the consequences of any vapour clouds that may be produced when choosing a location for the tank.

Vapour clouds can be produced in two ways:

- (i) By water condensation, from air coming into contact with cold equipment during normal operation of a cryogenic system for example, from vaporisers.
- (ii) By the release of product from venting during liquid transfer, from the operation of protective devices or from liquid leakage.

Vapour clouds from releases are generally low lying (typically below waist height). Such vapour clouds are dependent on the weather conditions and may be quite extensive. The greater the wind, the quicker any product will dilute and disperse.

Vapour clouds may restrict visibility, however the release of product has the potential to create additional hazards, such as low temperature, flammability and asphyxiation.

Persons working below ground or at low level in the vicinity may be at risk. The extent of the visible vapour cloud resulting from product release should not be relied upon to indicate the limit of a depleted oxygen atmosphere or an area of increased fire risk.

When siting an installation, due consideration shall be given to the possibility of the movement of vapour clouds and the associated hazard from oxygen deficiency, increased fire risk or decreased visibility, for example, crossing roads. The prevailing wind direction and the topography shall be taken into account.

4.6 Vent systems

Vent systems are required to ensure gases are released safely, refer to Section 3.8.

All vents, including those of safety relief devices and purge valves, shall be connected to a vent stack. Vent stacks shall be made of materials compatible with the products being vented and be capable of withstanding cryogenic (low) and product combustion (high) temperatures.

The vent stack(s) shall be dedicated to a specific gas and not connected to other vent stacks; this will avoid back feed.

A flare stack is not normally required. If there is a local requirement for a flare stack then this shall be subject to an independent assessment. For the purpose of this section references to vent stacks shall be non-flared.

Consideration should be given to providing duplicate vent stacks for tank relief systems, such that the failure of one vent stack, for example, by a blockage, will not prevent the safe operation of the tank relief system.

The location and height of the vent stack shall always be subject to local risk assessment and should observe the minimum recommended separation distances, refer

to Section 4.4. The risk assessment shall consider the impact of potential thermal radiation from ignited product on the tank, other equipment and personnel. Consideration shall also be given to any environmental impact and the outcome of the DSEAR (12) risk assessment.

All vent systems shall be adequately supported to cope with loads created during discharge, as well as those created by the weather, for example, wind etc. Where the vent system is attached to the shell of the storage tank the design should be such that excessive stress is not applied to the tank shell either under discharge or foreseeable weather conditions, in addition appropriate precautions should be taken to ensure that cracking is not induced in the shell as a result of welding operations.

Current industry practice for a hydrogen vent is to locate it at a minimum height of 7 metres above ground level or 3 metres above the top of the tank or any equipment used to support it, for example, the vaporiser; whichever is the greater for protection of the operating personnel and equipment.

For CNG the height of the vent stack should be a minimum of 3 m above ground level and a minimum of 1 m above the top of the tank or any equipment used to support it, for example, the vaporiser; whichever is the greater for protection of the operating personnel and equipment, refer to IGEM UP/20 (89).

The vent stack outlet shall discharge in a safe place in the open air so as to prevent impingement of escaping gas and/or liquid on to personnel, on equipment or structures (especially steelwork), for example, tank shell and support structures

The vent stack shall not discharge where accumulation of flammable gases can occur, such as below the eaves of buildings.

During the filling process there is a potential for liquid product to be released through the vent outlet.

Flammable gas or liquid vents shall be so positioned that the flow from them cannot mix with that from oxygen vents.

Consideration should be given to the height of adjacent buildings as these may affect the circulation of natural air and may be in the path of venting gas clouds.

The design of the vent stack outlet shall prevent the accumulation of foreign bodies and water, including that from snow, rain and condensation. Any water accumulation may lead to the formation of ice which could potentially cause blockages. Therefore, it is recommended that a ball valve, with a self-closing mechanism, as a drain, with water collection below the lowest entry point into the stack is installed.

A notice shall be clearly displayed, to be visible at all times, on or near the vent stacks, particularly at access points, to indicate that water is not to be sprayed on vent stacks, refer to Section 5.4.

All vent outlets shall be identified by a warning sign highlighting the hazard from flammable gas. Refer to Section 5.4, for an example, refer to Figure 1.

A wind direction indicator may assist, refer to Section 5.4.5.

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

4.7 Equipment layout

The equipment shall be installed so as to provide for easy access, operation and maintenance. Consideration should be given to the location of valves pipework and controls etc. to ensure these are easily accessible for operational and maintenance purposes. Equipment, pipework and cables should be installed so as to minimise hazards, for example, tripping, and to allow safe access and egress to the installation.

4.7.1 Vaporisers

Pressure build-up and production vaporisers may be an integral part of the tank assembly, or may be added as part of the installation.

NOTE: Vaporisers can be a cause of vapour clouds caused by ambient air coming into contact with air cooled by the vaporiser and water condensation taking place.

The position of ambient vaporisers can severely affect their performance, as they rely on the free movement of air.

As necessary, trim heaters may be required on the outlet of the ambient vaporisers to ensure the outlet gas is at the required temperature for the process. The location of trim heaters should facilitate maintenance activities. Trim heaters will require a power source, for electrical requirements refer to Section 4.9.6.

4.7.2 Ventilation of ancillary equipment

Where pumps and / or vaporising equipment are located in enclosures, these shall be properly ventilated. Openings used for access and/or free or forced ventilation shall lead to a place where there is free escape for cold vapour and where there will be no accumulation of combustible material liable to form a hazard.

4.7.3 Ancillary equipment

Ancillary equipment is to be located to facilitate ease of use and maintenance, access and egress.

4.7.4 Pipework

Pipework shall comply with the requirements of BCGA CP 4 (74), *Industrial gas cylinder manifolds and gas distribution pipework (excluding acetylene)*.

The material of construction shall be compatible with the gas, pressure and temperature, refer to Section 4.9.1.

Pipework should be identified with its contents, refer to Section 5.4.2. Where pipework is protected by insulation materials then the identification markings are to be on the outside of the insulation.

Where pipework contains a cryogenic liquid then:

- Protection is provided against thermal expansion, refer to Section 4.9.3.

- A significant amount of ice build-up on cold surfaces can develop caused by the freezing of atmospheric moisture, this can lead to:
 - Excess weight on pipes and equipment.
 - Hinder the function of relief valves.
 - Prevent access to valves etc.
 - Hinder access to personnel.

The use of insulation should be considered where other design or engineering solutions are not practical.

- Where it is a requirement to maintain the product as a cryogenic liquid then pipework should be insulated, for example using a Super Insulated Vacuum Line (SIVL), and kept as short and as straight as is reasonably practical.

Pipework should be positioned such that any potential leak points are located in areas where any product that is released will not affect the mechanical integrity of the tank or its support structure, refer to Section 4.9.8.

4.7.5 Lighting

Adequate lighting shall be provided to allow for the identification of the product(s) (signage and labels), to allow normal maintenance operations, manual handling activities and deliveries to be undertaken safely, as well as to assist with security. The light source used shall give suitable colour rendering to enable colour labelling to be easily recognised by persons with normal colour vision. Lighting is required to be appropriately located, the location of any lights should take into account vent outlets and potential release points, these are to be avoided. Electrical equipment shall comply with the requirements of Section 4.9.6. Where required, emergency lighting shall be to the requirements of BS 5266 (39), *Emergency lighting. Code of practice for the emergency escape lighting of premises.*

4.7.6 Gas detection

Where gas detection is identified as necessary within the risk assessment, suitable gas detectors are to be fitted, electrical equipment shall comply with the requirements of Section 4.9.6.

For information on gas detectors refer to BS EN 60079 (53), *Explosive atmospheres – Part 29-2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen.*

The locations for the gas detection equipment shall take into account the physical properties of the respective gases, potential release points and areas where they may accumulate. Audio / visual alarms, along with appropriate warning notices, safety signs and instructions (refer to Section 5.4), shall be positioned at each

entrance to the protected area, at strategic locations within the area and at control centres, as determined by the risk assessment.

Alarm levels are to be set to allow action to be taken in the event of a release of product, providing an early warning system, but not such that it creates false alarms. Thus allowing time for personnel to evacuate the area before hazardous conditions are reached i.e. flammability range and/or workplace exposure limits are reached.

NOTE: Typically for a flammable product the alarm should be set at 50 % of the lower flammable limit in air. The sensitivity and characteristics of gas detectors vary, therefore it is recommended that you seek the manufacturer's advice.

Detection equipment should be installed, maintained and tested in accordance with the manufacturer's recommendations.

Alarms should be tested regularly.

All systems should be fail safe and programmable devices should have an appropriate SIL (Safety Integrity Level) rating.

The gas detection system and/or any process control system, may interface with the emergency shut-down system.

4.7.7 Emergency shut-down system activation

The manual activation of the emergency shut-down system shall be positioned at each entrance to the tank compound, and at strategic locations within the area and at remote locations, as determined by your risk analysis. Emergency shut-down activation devices should be positioned to be visible, clearly identified and within easy reach, to allow quick and easy operation in an emergency situation taking into consideration any PPE that may be worn.

For information on the means of isolation refer to Section 4.9.5.

Other systems if installed, such as the gas detection system and / or any process control system, may interface with the emergency shut-down system. The emergency shut down system shall operate independently of the process control system.

NOTE: A fail-safe design will ensure that in the event of any utility failure the emergency shut-down system will isolate the tank and its contents.

The emergency shut-down system shall incorporate a suitable and sufficient risk based procedure to reset the system. Such a procedure may require it being reset by an authorised person once operated.

4.8 Installation of the tank

4.8.1 Foundations

The tank supplier will provide indicative foundation requirements but it is the responsibility of the user to ensure the tank foundation is designed to safely

withstand the weight of the tank and its contents plus other possible loads resulting from wind, snow, earthquake, blast induced ground vibration, etc.

NOTE: The tank supplier may require confirmation from a competent person that the foundations meet the required specification.

The foundation on which the equipment is installed shall be made of concrete or any other suitable, non-flammable, and non-porous material. The use of hydrocarbon based products, such as asphalt, shall be avoided.

Expansion joint materials shall be compatible with the product in the tank, however the design should avoid joints within 1 m of the hose coupling points and any operational discharge points.

Earth bonding to the rebar (in the concrete) is strongly recommended. Refer to Section 4.9.7.

Tank supports and structures shall be manufactured from non-combustible materials. Where the mechanical integrity of the support structure may be affected by a cryogenic liquid spillage then the structure shall be protected, refer to Section 4.9.8.

The design of the foundations and support structure shall avoid the accumulation of water.

All foundations shall be separated from ducts, manholes, gullies, drains, service trenches. For minimum recommended separation distances refer to Section 4.4.

4.8.2 Bolting down

Many factors determine whether and how a tank needs to be bolted down. The following are some of the main factors that should be considered:

- Seismic activity.
- Wind load.
- Topography (nature of surrounding terrain).
- Ground roughness (open or protection provided).
- Tank shape factor (Length/Diameter ratio, attachments to tank).
- The potential to tip the foundation.

NOTE: Horizontal tank installations are designed to allow movement due to thermal changes. Typically one end of a tank is fixed and the other allows for movement.

The principles of BS EN 1991 (36), *Eurocode 1. Actions on structures*, shall be followed to determine bolting down requirements.

4.9 Design and manufacture of the tank

Tanks and associated equipment shall be designed, manufactured and installed in accordance with recognised pressure vessel, storage tank and piping codes that meet the requirements of the Pressure Equipment Regulations (8).

Tanks containing a gas at a pressure of less than 0.5 bar above atmospheric pressure are not covered by the Pressure Equipment Regulations (8). However, in order to comply with Regulation 4 of The Provision and Use of Work Equipment Regulations (PUWER) (6), the tank should be properly designed and properly constructed from suitable material so as to prevent danger. This is best guaranteed by adherence to a recognised design standard for this type of tank and its intended use, following the principles of the Pressure Equipment Regulations (8).

All tanks and associated equipment shall have their electrical installations provided to approved standards and all metal fittings shall be adequately earth bonded, refer to Section 4.9.6 and Section 4.9.7.

Where appropriate, tanks shall be designed to withstand wind loads in accordance with the appropriate design codes, for example, BS EN 1991-1-4 (36), *Eurocode 1. Actions on structures. General actions. Wind actions.*

4.9.1 Materials

All components shall be constructed from materials compatible with the cryogenic flammable fluid in service, and with the temperature and pressure conditions to which they will be subjected. Refer to Section 3.4.1.

Under certain conditions pressurised pure hydrogen can cause ambient temperature embrittlement of welded carbon steel fabrications. The selection of materials for hydrogen storage tanks and components needs careful consideration. Refer to EIGA Document 15 (58), for additional information.

Consideration should be given to the possible formation of liquid air on the surface of equipment containing cryogenic liquids when selecting materials for use in the construction for tanks, including all insulation, piping, valves, gaskets, seals and instruments.

These considerations shall be also taken into account when designing pipework systems and their accessories connected to the tank, for example fill, product withdrawal and vent lines.

The selection and use of materials and joining procedures shall be carefully considered in the design to avoid secondary failure in the event of external fire.

The design of the vessel support structure shall take into account the possibility of fire impingement. Appropriate precautions shall be taken, for example, installation design, thermal insulation, fire-fighting methods.

4.9.2 Tank pressure relief devices

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

Each tank shall have pressure relief devices on both the inner vessel and outer jacket. Inner vessels shall be protected by at least two independent safety devices to take into account the failure of one of these devices. Typically, two safety devices of differing pressures will be fitted. Safety relief systems should comply with BS EN 13648 (50), *Cryogenic vessels. Safety devices for protection against excessive pressure*.

At least one online pressure relief valve shall have a capacity and set-point that will prevent the pressure within the vessel exceeding the maximum allowable working pressure in accordance with the applicable vessel design code.

EIGA Document 24 (60), *Vacuum insulated cryogenic storage tank systems pressure protection devices*, provides a code of practice for pressure protection devices for static cryogenic vacuum insulated storage tanks.

Pressure relief devices shall be arranged to allow unobstructed discharge to atmosphere. All relief devices shall relieve through the vent system, refer to Section 4.6. Installation design shall ensure that the risk of pressure relief and vent line blockage is minimised, and that intended purge and vent operations can be safely and effectively carried out.

For sizing the relieving capacity of pressure relief devices all operational conditions shall be considered including:

- Boil off rate (including a safety factor) in case of insufficient insulation due to loss of vacuum.
- Filling operations of road tankers.
- Malfunction of control valves in pressure raising systems; or
- Any other foreseeable source of energy input into the vessel i.e. fire, pump recycle systems, production plant.

NOTE: Before the first fill of a tank the gas supplier will assess the tank and its pressure relief system to ensure adequate pressure protection during filling, taking into consideration the pump discharge characteristics. Refer to BCGA GN 17 (82), *BCGA policy and guidance for the safe filling of third-party owned and / or maintained tanks*.

A diverter valve (commonly referred to as a three-way valve) may be fitted for the purpose of alternating between primary and back-up pressure relief devices. This is used to facilitate maintenance and replacement of devices while the tank is in service. The size of the diverter valve and the inlet pipework shall be such that the vessel is always adequately protected. Where appropriate, the diverter valve should be provided with a position indicator showing which relief devices are 'on line'. Consideration shall be given to the ease of access to the diverter valve for operation when a relief device is discharging. For the capacity of pressure relief devices refer to EIGA Document 24 (60).

The pressure relief device outlet pipework will impose back-pressure which shall be included in the relief valve sizing calculation. The working temperature of

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

Installation and orientation of the relief device shall be in accordance with manufacturer's recommendations. This will prevent the accumulation of water or other contamination, which could result in incorrect operation, for example by freezing. Consideration shall be given to the thrust resulting from operation of the relief device and the effect on the pipework. Provision of additional supports may be required to control imposed thrust forces.

Outer jackets of static tanks need not be designed to a pressure vessel design standard, but they shall be capable of withstanding full vacuum. Outer jackets shall be fitted with a device to relieve pressure increase in the event of a leak from the inner vessel.

4.9.3 Protection against thermal expansion

Protection against over pressure shall be installed between any two isolation valves or items of equipment, where liquid or cold vapour can be trapped.

All vents shall discharge into the vent system, refer to Section 4.6.

4.9.4 Isolation valves

The primary isolation valves shall be located as close as practical to the tank itself and be easily accessible. The position of isolation valves should be such that they can be afforded adequate protection against damage from external sources.

A secondary means of isolation shall be provided for pipes emanating from below the liquid level that are:

- Greater than 9 mm bore and exhausting to atmosphere; or
- Greater than 50 mm bore when forming part of a closed system; or
- Have only one means of isolation between the tank and the atmosphere (such as liquid filling pipes).

The secondary means of isolation, where provided, may be achieved, for example, by the installation of a second valve, positioned so that it can be operated safely in emergency, an automatic fail-closed valve or a non-return valve or fixed or removable cap on the open end of the pipe.

The secondary means of isolation may be within the user installation and shall provide an equivalent level of protection.

For additional information on LNG refer to BS EN 13645 (49).

4.9.5 Emergency shut-down valves

For tanks with a capacity of five tonnes and greater, an emergency remotely operated shut-off valve shall be fitted close to the tank on the liquid phase of the filling and supply pipes. The valve actuator shall be fitted with a mechanical, pneumatic or electrical position indicator. The remotely operated valve(s) shall be fail-safe, that is, in the event of a power or control system failure it should close. Consideration should be given to fitting these for tanks below 5 tonnes capacity.

All connections between the tank and the emergency shut-down valve shall be welded. The emergency shut-down valve shall be fire safe. Fittings shall be designed so that they continue to function to the necessary extent at the temperatures to be expected in the event of a self-produced fire.

For further information refer to:

- BS EN 13458, Part 2 (48), *Cryogenic vessels. Static vacuum insulated vessels. Design, fabrication, inspection and testing*; and
- BS EN ISO 10497 (45), *Testing of valves. Fire type-testing requirements*.

4.9.6 Protection against electrical hazards

All electrical installations shall, as a minimum, conform to BS 7671 (44), *Requirements for electrical installations. IET wiring regulations*.

All fixed electrical equipment located in hazardous zones shall have the appropriate ATEX rating, refer to BS EN 60079 (53), *Explosive atmospheres. Part 14, Electrical installations design, selection and erection*. Different fuels may require different ATEX gas group classifications, for instance, hydrogen installations require equipment rated for gas group IIC hazardous areas (due to the low ignition energy of hydrogen).

NOTE: ATEX is the name commonly given to the two European Directives for controlling explosive atmospheres. These are:

- European Directive 99/92/EC (18) (also known as 'ATEX 137' or the 'ATEX Workplace Directive') on minimum requirements for improving the health and safety protection of workers potentially at risk from explosive atmospheres.
- European Directive 94/9/EC (17) (also known as 'ATEX 95' or 'the ATEX Equipment Directive') on the approximation of the laws of Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres.

In the UK the requirements of the ATEX Workplace Directive (18) were put into effect through DSEAR (12). The requirements of the ATEX Equipment Directive (17) were implemented by the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations (EPS) (3). Compliance with DSEAR (12) and the EPS

Regulations (3) is sufficient to confirm compliance with the ATEX Workplace Directive (18) and ATEX Equipment Directive (17) respectively. Further guidance is available in HSE L138 (25), and additional information is available in EIGA Document 134 (66), *Potentially explosive atmospheres EU Directive 1999/92/EC*.

An area classification drawing shall be prepared, indicating the requirements for the use of appropriately classified electrical equipment, as required under DSEAR (12). All electrical equipment shall then comply with these requirements. Refer to BS EN 60079, Part 14 (53) for further information.

All other fixed electrical equipment is to be located with reference to the minimum recommended separation distances, refer to Section 4.4. A risk assessment shall be carried out to assess the suitability of portable electrical, electronic devices and other equipment for use in a flammable area. As required, appropriate controls are to be applied, for example, flammable gas monitoring.

Where applicable, electrical equipment, which is necessary for the installation shall be to BS EN 60529 (54), *Specification for degrees of protection provided by enclosures*, protection class IP54 or better. For more severe environmental conditions protection class IP55 (designed to protect against water jets) should be used.

Mechanical equipment can also be a source of ignition, refer to Section 3.7.

4.9.7 Protection against lightning and static and electrical bonding

All metal fitments in the facility including fencing, gates, tanks and all pipework shall be adequately earth bonded, refer to BS 7430 (43), *Code of practice for protective earthing of electrical installations*. The entire system shall be continuously electrically earthed with a maximum resistance to earth of 10 Ω . The earthing connections should be installed prior to a flammable mixture being present and the commissioning of the system. This shall include an effective earthing point for the delivery vehicle. The earth rod for static earthing shall be connected to earthing for electrical supplies or lightning discharges. Regular inspection, and as necessary maintenance, of the bonding system shall be carried out.

Earthing can be done via:

- Separate earthing wires: diverter resistance $\leq 2 \Omega$.
- Foundation earthing, ground earthing, combined use of earthing: diverter resistance $\leq 10 \Omega$.
- Installation on earth without intermediate insulation: diverter resistance $\leq 10^6 \Omega$ (only permissible for diverting electro-static charge).

For additional information refer to BS EN ISO 21009, Part 2 (51), *Cryogenic vessels. Static vacuum insulated vessels. Operational requirements*.

Lightning protection may be necessary to comply with local conditions or site regulations. Lightning protection should be considered and implemented as

appropriate, refer to BS EN 62305 (55), *Protection against lightning*, for further information.

Major items of equipment such as the tank and vaporisers shall be bonded directly to the earth point and not rely upon the piping as a means to earth. Earth bonding to the rebar (in the concrete) is strongly recommended.

4.9.8 Protection against impingement from cryogenic fluids

The design and lay-out of pipework shall minimise the risk of a leak occurring. The most likely place for a leak to occur is from joints, glands, couplings etc. Where practical, pipework should be positioned such that any potential leak points are in places where any product that is released will not affect the mechanical integrity of the tank and its support structure. Where this is not achievable then appropriate protection shall be provided, for example thermal insulation. Refer to Section 4.7.4.

Consideration shall be given for provision to divert any spillage towards the safest available area.

4.9.9 Instrumentation

Sufficient instrumentation is required to enable the tank to be commissioned, operated and de-commissioned in a safe manner. Instrumentation shall include at least the following measurements:

- Liquid level. The vessel shall be equipped with two independent systems, one with a continuous indication.
- Pressure. A pressure gauge connected above the maximum liquid level shall give a continuous indication.

The design should allow for the maintenance of instruments by avoiding the need to decommission the tank.

All the control equipment for the safe operation of the installation shall be easily accessible to the plant operations personnel and delivery driver. All instrumentation shall be clearly visible.

4.9.10 Protection against overflow

Vessels shall be equipped with at least one device against overflowing (try-cock or level limiter) – this should not be part of a differential pressure level indicator. Vessels with a capacity of more than 50 tonnes shall be equipped with a minimum of two independent devices which provide protection against over filling, whereby one device may be incorporated in the level indicator. The two devices protecting against overflowing should operate with different measuring methods. Refer to BS EN 13458, Part 2 (48).

4.9.11 Hoses

All hoses are to be compatible with the product, temperatures and pressures. Protection against over-pressurisation shall be provided. All hoses shall be manufactured to an appropriate design standard. Examples include:

- BS 4089 (37), *Specification for metallic hose assemblies for liquid petroleum gases and liquefied natural gases*;
- BS EN 1762 (35), *Rubber hoses and hose assemblies for liquefied petroleum gas, LPG (liquid or gaseous phase), and natural gas up to 25 bar (2,5 MPa). Specification*; and
- BS EN 12434 (47), *Cryogenic vessels. Cryogenic flexible hoses*.

4.9.12 Markings

The tank shall be marked in accordance with the requirements set out in the Pressure Equipment Regulations (8), [Schedule 2, Paragraph 3.3]. The safe operating limits should be clearly defined.

The contents of the tank shall be identified as detailed in Section 5.4.2.

4.10 Liquid transfer area

The liquid transfer area, the access apron and the transfer of product, shall be included as part of the DSEAR (12) Risk Assessment for the installation. Refer to Section 3.5.

A road tanker, when in position for filling from or discharging to the installation, shall be in the open air and not be in an enclosure from which any unintended escape of liquid or heavy vapour is restricted. Road tankers should have easy access to and from the installation at all times without any additional manoeuvring.

The liquid transfer area should normally be located adjacent to the tank. Extended fill lines should be avoided if possible; where they are required the length shall be kept to a minimum. Extended fill lines shall not be constructed from flexible hose. Where extended fill lines are necessary this shall be considered as a specific requirement in the risk assessment, refer to Section 5.1. The driver / operator shall remain in line-of-site of the controls and instrumentation and in a position to provide emergency shut-down. Unless the tank is specifically designed for remote filling, suitable 'repeater' gauges and valves should be installed at the extended fill point.

Transfer of liquid with the road tanker positioned in an area normally accessible to the public should be avoided. However, if this cannot be avoided, the hazard area shall be clearly defined, using suitable notices during the transfer period. Access to this area during transfer shall be strictly controlled. During product transfer, the area is only to be used for that purpose. If the delivery operation cannot be contained within a fenced off area, temporary demarcation should be used to control access to only authorised persons during the delivery process.

The liquid transfer area shall be made of concrete or any other suitable non-porous non-combustible material, including any expansion joints, in-line with Section 4.8.1. The liquid transfer area should be level, with sufficient slope to provide normal surface water drainage.

An earthing point shall be provided within the liquid transfer area, in a location that will allow road tankers to connect the tanker earth cable, refer to Section 4.9.7. Delivery vehicles require to be earthed prior to the connection of the hoses, and to remain connected until all hoses are disconnected.

Adequate lighting shall be provided, refer to Section 4.7.5.

Fire protection equipment is to be provided as necessary, refer to Section 4.2.

The liquid transfer area should be designated a 'No Parking' area. Appropriate notices should be displayed.

Points for consideration in setting out the liquid transfer area:

- (i) Protection of the tank(s) and pipes from vehicle impact, for example by barriers, bollards or kerbs;
- (ii) Avoiding wherever possible the requirements for delivery vehicles to reverse;
- (iii) Hose lengths required from delivery vehicle parking position to tank fill coupling;
- (iv) Hose handling arrangements (for example, parking post, storage space, weather protection, capping, etc.);
- (v) Practical methods for preventing a tanker being moved away while still connected to fixed equipment, for example, the failure to disconnect the product delivery hose(s) that connect the tanker to the storage tank fill point. For more information refer to EIGA Document 63 (64), *Prevention of tow-away incidents*.
- (vi) Emergency arrangements for delivery vehicles and the delivery team (including a requirement for the vehicle being able to drive away unhindered in a forward direction in the event of an emergency);
- (vii) Demarcation of the delivery vehicle parking location;
- (viii) Signage, lighting and surface condition;
- (ix) Drainage and spill arrangements from the delivery area;
- (x) The construction of the delivery pad surface, taking account of the actual delivery vehicle weight, size and layout;
- (xi) Line-of-sight maintenance from vehicle control position to tank gauges and indicators;
- (xii) If installation is situated on a vehicle filling station, line-of-sight maintenance from station control position to the tanker stand;
- (xiii) The position of any sensors, alarms, alarm repeaters, indicators etc. for the use of the delivery team including the on-site competent person;
- (xiv) Tanker earthing point (and any necessary signage);
- (xv) Restriction of access to the liquid transfer area when deliveries are being made;

(xvi) Restriction of access to the liquid transfer fill connections when deliveries are not being made;

(xvii) Special site rules which may need to apply during (and immediately before and after) deliveries;

(xviii) The impact on the site zoning under DSEAR (12).

At sites where multiple fuels are stored or dispensed, simultaneous bulk deliveries of differing fuels shall not be permitted.

Refer to Appendix 3 for a diagrammatic view of a liquid transfer area.

4.10.1 Couplings

Tank fill couplings shall not be interchangeable with other products. Care should be taken when filling 3rd party tanks that the appropriate coupling is used. For further advice on a range of cryogenic couplings refer to EIGA Document 909 (71), *EIGA Cryogenic gases couplings for tanker filling*.

4.10.2 Backflow prevention

Suitable devices shall be fitted to prevent backflow, over-pressurisation or contamination from the storage tank to the tanker.

4.10.3 Instrumentation

EIGA Document 07 (57), *Metering of cryogenic liquids*, gives guidance on the general principles that should be followed for setting the conditions under which cryogenic liquids can be satisfactorily metered during transfer.

5. MANAGEMENT AND CONTROL OF THE INSTALLATION

5.1 Security

A security risk assessment shall be carried out and appropriate control measures introduced. The site to be kept secure at all times. Access points are to be kept locked when not in immediate use. Keys are to be held in a secure place and issued only to suitably trained and authorised personnel. The contact details for the authorised key holder shall be displayed. Access to the installation shall be forbidden to all unauthorised persons. Warning notices shall support this. Refer to Section 5.4.

Adequate lighting shall be provided to assist in the security of the site, refer to Section 4.7.5.

Where electronic security systems, for example, alarms, are installed comply with the electrical requirements of Section 4.9.6.

5.2 Personnel

All personnel accessing the site are to have received suitable and sufficient training on the safe operation of the installation, the product hazards, operation and awareness of alarms and emergency procedures. Refer to Section 8.

Appropriate PPE shall be worn. Refer to Section 3.3.7.

5.3 Access to installation controls

Access to filling connections and equipment controls is to be restricted to authorised personnel.

Filling connections and equipment controls should be located in close proximity to each other and in such a way that tanker controls and indicators are visible and easily accessible from the tanker operator's position.

5.4 Warning notices, safety signs and instructions

Appropriate warning notices, safety signs, pictograms and instructions shall be displayed and maintained in good condition. These signs shall comply with the Health and Safety (Safety Signs and Signals) Regulations (4) and with BS EN ISO 7010 (42), *Graphical symbols. Safety colours and safety signs. Registered safety signs*. For additional advice refer to HSE L64 (21), *Safety signs and signals. The Health and Safety (Safety Signs and Signals) guidance on regulations*.

A pictogram should be used instead of written notices wherever possible. For examples refer to Figure 1.

Boundary warning notices, safety signs and pictograms shall be clearly visible from all angles of approach, preferably sited with the centre of the sign at the average eye level (between 1.5 and 1.7 m above the ground).

All displayed notices shall be kept legible, visible and up-to-date at all times.

5.4.1 General precautions

The following notices shall be clearly displayed on or near the tank, and as appropriate on the boundary, particularly at access points:

- LIQUID xxxxxx (*as appropriate*)
- FLAMMABLE GAS
- NO SMOKING
- NO NAKED LIGHTS
- NO SOURCES OF IGNITION
- NO MOBILE PHONES OR OTHER ELECTRONIC DEVICES
- NO STORAGE OF OIL, GREASE OR COMBUSTIBLE MATERIALS
- AUTHORISED PERSONS ONLY
- CRYOGENIC LIQUID
- EXTREME COLD HAZARD
- ASPHYXIATION HAZARD

The following notices shall be clearly displayed on or near the vent stack(s), particularly at access points. Refer to Section 4.6.

- DO NOT SPRAY WATER ON VENT STACK
- FLAMMABLE GAS

With flammable gases there is a risk of the development of an explosive atmosphere. In accordance with DSEAR (12) it is necessary to display the explosive atmosphere “EX” sign. Refer to Figure 1.

These signs shall be supplemented by a flammable material warning triangle.

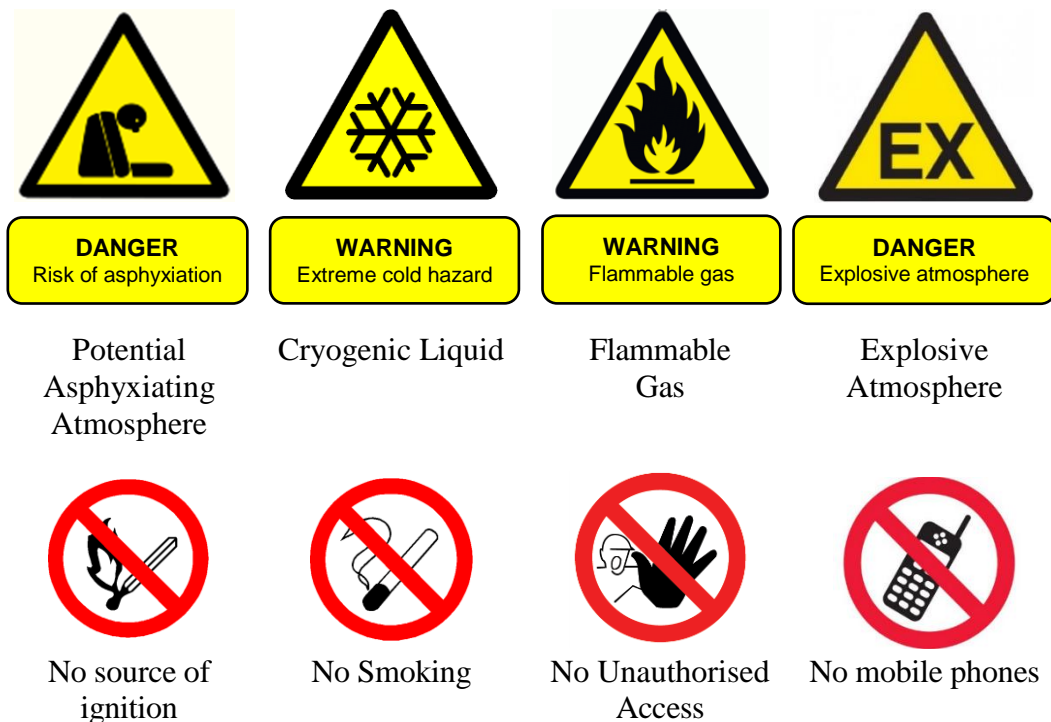


Figure 1: Example warning notices and safety signs

A sign shall be displayed showing:

- (a) Actions to take in the event of an emergency.
- (b) The site operator’s routine contact details.
- (c) Emergency contact information including an emergency phone number, for example of the gas supplier and/or the site operator.
- (d) The emergency services phone number.

This information should also be available at a control point, for example, the site control room, site security.

5.4.2 Identification of contents

The storage tank shall be clearly labelled “LIQUID xxxxxx” as appropriate.

The storage tank or compound should be clearly labelled with the appropriate UN number(s) as defined in the United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations. (16).

The connection fittings of multi-storage installations, long fill lines and pipework shall also be clearly marked with gas name or symbol, refer to Section 4.7.4.

5.4.3 Identification of valves and operating devices

All valves and operating devices shall be clearly marked to show their functionality and/or to reference them against the process and instrumentation diagram (P&ID). For convenience the hand wheels of valves may be colour coded or identified by other means in particular to indicate those valves which are to be shut in an emergency. These valves should normally be:

- Feed and return valves to and from the pressure build up vaporiser.
- Feed valve to the product vaporiser.
- Customer supply line isolation valve.
- Any withdrawal valve.

5.4.4 Operating and emergency instructions

Operating and emergency instructions shall be provided and shall be available and understood by the user during the handover of the installation. Refer to Section 6.2.6.

These instructions shall be kept up-to-date.

5.4.5 Wind indication

The Fire Safety Management Plan may require that an easily visible wind direction indicator is installed in the area of the cryogenic flammable fluid storage tanks, for example, a wind sock. Where tanks with a capacity of more than 50 tonnes are located a wind direction indicator shall be installed. If due to the nature of the installation a local wind direction indicator is not practical, the wind direction may be indicated centrally at an appropriate point that would be clearly visible to the emergency services.

6. TESTING AND COMMISSIONING

A written procedure shall be established which shall define the Responsible Person(s) and the test and commissioning process for the installation. Before work commences, ensure that all relevant personnel are aware of the work being carried out and have adequate information and instruction on the actions to be taken in the event of an incident. Testing and commissioning shall only be carried out by competent personnel.

The written procedure shall ensure that any significant risks are addressed, including:

- Thermal shock.
- Rapid pressure rise.
- Sources of ignition.
- Noise.
- Gas release.

6.1 Testing

6.1.1 Pressure and leak test

Works manufactured storage tanks and pressure vessels of will already have been tested / inspected in compliance with the relevant Pressure Vessel Code in the manufacturer's workshop prior to the first installation. This should be verified from the name plate attached to the vessel. Further pressure tests shall not be carried out on the vessel without reference to the vessel design documents and tank history.

In order to ensure the integrity of the installation, a pressure test shall be carried out on site-erected piping / systems in accordance with design codes and appropriate standards. Precautions shall be taken to prevent excessive pressure in the system during the test. Following any hydraulic test, the system / equipment shall be drained, thoroughly dried out and checked for moisture content.

When a hydraulic test is not practicable or is precluded because of the design of the system, the strength test may be carried out pneumatically, commencing with a leak test. Nitrogen or dry oil-free air shall be used as the test medium. The pressure in the system shall be increased gradually up to the test pressure.

NOTE: Hydraulic testing is considered to be a far safer method than pneumatic testing as the potential release of stored energy upon component failure is substantially less. Pneumatic pressure testing should be carried out in accordance with HSE Guidance Note GS4 (26), *Safety requirements for pressure testing*.

Pressure tests / leak tests shall be witnessed by a competent person and a test certificate signed and issued. Such certificates shall be kept as part of the technical file for the life of the item.

A leak and function test using an inert gas at operating pressures shall be carried out using suitable leak detection methods. It is recommended that helium or a helium / nitrogen mixture is used as the test medium for hydrogen systems, this has the advantage of also inerting the system prior to first fill.

Any defects found during the testing shall be rectified in an approved manner and the system then retested.

6.1.2 Pressure relief devices

A check shall be made to ensure that:

- All the necessary pressure relief devices are fitted, and that they are appropriate for their purpose.
- All transport locking devices have been removed from pressure relief devices of inner vessel, outer jacket and piping systems and that the pressure relief devices are undamaged and in working order.
- The pressure relief device set pressure (stamped on or attached to each device) is appropriate for the maximum permissible operating pressure of the system.
- That all outlets are clear.
- Pressure relief valves have a valid test certificate or are covered by an appropriate batch test certificate or are subjected to a successful functional test the results of which shall be recorded.
- All pressure relief devices are in-date and that they conform with the manufacturers recommendations and the PSSR (9), Written Scheme of Examination.
- Tamper proof devices are fitted to pressure relief devices that are adjustable.

6.1.3 Adjustment and setting of process and other safety devices

A check shall be made to ensure that:

- All process and safety devices are installed, adjusted to their operating conditions and, where practical, subjected to a functional test.

Examples include:

- Emergency shut-down devices;
- Level gauges;
- Pressure regulators and gauges;
- The positioning of process valves.
- That the over-pressurisation protection system is compatible with the gas suppliers dispensing system and that over-pressurisation cannot occur during filling. Refer to EIGA Document 151 (69), *Prevention of excessive pressure during filling of cryogenic vessels*.
- That overflow protection is provided. Refer to Section 4.9.10.

6.1.4 Warning notices, safety signs and instructions

Warning notices, safety signs and instructions shall be posted around the installation prior to the first fill, refer to Section 5.4.

Check that suitable warning and identification labels are clearly displayed on the tank, process and operating valves, and that they are correct for the product being stored.

6.1.5 Fire safety and emergency preparedness

A check shall be made to ensure that:

- That a fire risk assessment has been carried out and incorporated into the Site Fire Safety Management Plan and all required fire-fighting equipment is installed and operational. Refer to Section 4.2.
- That emergency procedures have been drawn up, tested and implemented.
- That there are no sources of ignition or that there are no extraneous combustible products stored on site.

A test of the emergency shut-down system is to be carried out to ensure correct operation. Refer to Section 9.

6.1.6 Vents and ventilation

A check shall be made to ensure that:

- The ventilation around the whole storage area meets the criteria specified in Section 4.5.
- All vents flow into the vent stack and that the stack exhausts into a safe area. Refer to Section 4.6.

6.1.7 Installation design verification

A check shall be made to ensure that:

- The installation conforms to the P&ID.
- Back-feed from the process into the tank, for example, from high-pressure gas cylinders, is not possible.
- Liquid cannot become trapped in any part of the system not protected by thermal relief devices or reach parts of the system not designed for low temperature use, refer to Section 4.9.3.
- A DSEAR (12) Risk Assessment has been carried out and that associated hazard area classification drawings have been produced and are available, refer to Section 3.5. An explosive atmosphere sign is in place, refer to Section 5.4. All equipment is appropriately protected against electrical hazards, refer to Section 4.9.6. An explosion protection document

(EPD) is compiled for the tank, associated plant and equipment. Refer to EIGA Document 134 (66).

- The electrical installation has been certified by a competent person and electrical continuity checks have been carried out.
- The facility is earthed, including the tanker earthing point. Refer to Section 4.9.7.

6.1.8 Establish in-service requirements

The user, working with the installer, shall:

- Carry out an Ageing Pressure Equipment Assessment in accordance with BCGA CP 39 (77), with a competent engineer, to identify the in-service requirements.
- Produce a written scheme of examination, in accordance with the PSSR (9), with the competent person, and if required conduct an initial examination.
- Ensure that downstream pipework and equipment is compatible with the default supply temperature and pressure conditions.

6.1.9 Security

Check that the site is secure, a security risk assessment has been conducted and its requirements implemented. Refer to Section 5.1.

6.2 Commissioning

6.2.1 Inert purging

Before introducing a cryogenic flammable fluid the whole system must be purged with an inert gas to ensure that oxygen is reduced to a safe level to prevent a dangerous flammable oxygen mixture occurring. It shall be verified that the residual oxygen concentration is less than the minimum flammability level of the gas.

6.2.2 Product purging

Following the inert purge, the tank shall be purged with the product with which it will be filled. This will ensure product quality.

6.2.3 Pre-fill cooling

Carry out pre-cooling of the tank to minimize thermal shock and to minimize flammable venting during cool down. This can be carried out in combination with product purging. Consideration should be given to the likelihood of the purge gas condensing in this process.

6.2.4 First fill

Once all the above checks have been carried out satisfactorily and the applicable putting into service requirements of Section 7.1.1 and Section 7.1.2 have been complied with, the tank is ready to be filled in accordance with the manufacturers and gas supplier's instructions.

The first fill may either be carried out before or after the handover responsibilities detailed in Section 6.2.6. If first fill is carried out before handover, then the responsibilities during this transitional period need to be fully established.

6.2.5 Post-fill checks

Check the installation and the tank to ensure that:

- It does not leak;
- There is no abnormal icing on pipework;
- Readings on the pressure gauge are correct and stable;
- Readings on the level content gauge are within limits;
- There is no venting;
- It is not overfilled;
- There is no mechanical damage;
- There is vacuum integrity, in accordance with BCGA L11 (84), *Safety checks for vacuum insulated storage tanks*; look for excessive moisture, icing on tank skin, etc.;
- The tank is stable.

6.2.6 Handover

The responsibilities for the handover shall be clearly defined in writing.

The Responsible Person shall provide:

- Documentation which includes:
 - An operating manual covering safe operation and care of the installation, including emergency shut-down procedures.
 - Drawings (electrical, P&ID).
 - Information to allow a DSEAR (12) Risk Assessment to be maintained.
 - Test certificates.
 - Decommissioning requirements.
- A demonstration of the correct operation of the equipment.
- Training of user personnel in accordance with Section 8.

- The provision of a contact address and emergency telephone number should the user have any questions about his installation.

The user shall ensure he has all the necessary information to enable him to:

- Carry out his duties under the PSSR (9), including a Written Scheme of Examination.
- Carry out the required Risk Assessments, to meet legal duties and to implement a safe system of work.
- Develop an in-service inspection and maintenance programme including an Ageing Pressure Equipment Assessment, refer to BCGA CP 39 (77). To include arrangements to obtain appropriate spare parts.
- Identify and develop a training needs schedule / training plan, refer to Section 8.
- Ensure all the equipment can be operated safely.
- Allow standard operating procedures to be developed.
- Develop emergency procedures.

Prior to the introduction of flammable products into the installation the user shall ensure:

- DSEAR (12) Risk Assessment is complete and implemented. An explosion protection document is compiled.
- Duties under COMAH (14) are complied with, including any specific requirements, as applicable.
- Training needs schedule and training plan established. All personnel shall have been appropriately trained. Refer to Section 8.
- PPE assessments and requirements are complete and all personnel trained and issued with appropriate PPE.
- Written Scheme of Examination drawn up by the Competent Person.
- In-service inspection and maintenance programme in place, complete with an Ageing Pressure Equipment Assessment.
- Fire Risk Assessment has been carried out and incorporated into the site Fire Safety Management Plan, refer to Section 4.2.
- Site security plan in place, and personnel trained as appropriate.
- Operating Risk Assessment has been carried out and control measures implemented.

- Operating instructions are available and have been communicated.
- Emergency procedures developed, written instructions available. personnel trained, procedures practiced and ready for use. Refer to Section 9.

7. OPERATION AND MAINTENANCE

7.1 Operation of the installation

This is applicable not only during initial installation and commissioning, but during maintenance and normal use.

7.1.1 Putting into service (first filling) – Gas supplier responsibilities

The gas supplier shall:

- Provide a Safety Data Sheet for each product.
- Ensure that the user has a Written Scheme of Examination in place in accordance with the PSSR (9).
- Ensure the tank is safe for filling. Comply with BCGA GN 17 (82).
- Establish and agree with the user procedures for the safe filling of the tank, including emergency procedures. Ensure consent from the user for the fill.
- Obtain confirmation that the commissioning and the handover have been completed, refer to Section 6.
- Carry out a check that all valves used in the filling process are safely accessible, clearly identified and easy to operate.
- Check the tank is in a condition ready to receive the product with which it is to be filled. The tank has the appropriate safety and product signage fixed and clearly visible.
- Ensure that the product fill coupling is correct for the product, is secure and is in a serviceable condition. Refer to Section 4.10.1.
- Check measuring and control devices for correct operation.
- Carry out a check for leaks on filling pipework and fittings and report any leaks to the user.
- The tanker stand location and set-up is appropriate and allows the driver full control of the delivery process. Refer to Section 4.10.

7.1.2 Putting into service (first filling) – User responsibilities

The user shall:

- Read and comply with the requirements of the product Safety Data Sheet.
- Establish and agree with the gas supplier procedures for the safe filling of the tank, including emergency procedures.
- Provide evidence to the gas supplier that all elements of the commissioning and the handover have been completed, refer to Section 6.
- Ensure the tank has been purged with an inert gas, and is ready for first fill of the product.

7.1.3 Operation of the installation – User responsibilities

The user shall:

- Allow only authorised, trained persons to access and operate the installation. Refer to Section 8.
- Ensure the correct PPE is provided and used. Refer to Section 3.3.7.
- Control and manage portable equipment that may be a potential ignition source, such as mobile phones, electronic devices, torches and test equipment. Where these are necessary they are to be intrinsically safe and compliant with DSEAR (12) and the EPS Regulations (3).
- Installation operating instructions and emergency procedures, including process flow sheets, shall be permanently available and accessible to all relevant personnel.
- Monitor the operation of the installation for any operating difficulty or emergency. If during the operation an excursion occurs outside the safe operating limits of the system (for example, overpressure, rapid temperature change), or mechanical damage, this shall be reported immediately to the gas supplier and / or tank owner so that a decision about the continued use of the tank can be made and a programme of inspection drawn up by a competent person and implemented.
- Periodically review all documentation associated with the installation to check for relevance and continued applicability.
- Resolve any operating abnormalities, difficulty or emergency, concerning the installation that does not respond to measures covered by the operating instructions, referring to the equipment supplier, gas supplier and / or tank owner as appropriate.

- Maintain good housekeeping to prevent contamination by loose debris or combustibles.

7.2 In-service inspection and maintenance of the installation

The installation shall be periodically examined by a Competent Person in accordance with the Written Scheme of Examination to confirm its satisfactory condition for continued operation. Where defects are found they shall be investigated and rectified or appropriate mitigation carried out.

Carry out the in-service maintenance and inspection requirements identified in the Ageing Pressure Equipment Assessment, refer to BCGA CP 39 (77).

7.2.1 Tank installation

The user shall conduct the following routine safety checks:

- BCGA Leaflet 11 (84), provides a simple user guide to daily safety checks which should be carried out on vacuum insulated storage tanks. This will provide an early indication of any deterioration in the performance of the tanks insulation.
- BCGA Leaflet 12 (85) is a simple user guide that advises users and owners of liquid gas storage tanks on their legal responsibilities and duty of care to ensure that the equipment is maintained and operated safely.

7.2.2 Level indication and overflow protection

Overflow protection alarms or shutdown systems can be inactive for long periods and can develop undetected faults.

Hence the liquid level measurement system and the overflowing protection system shall be tested according to the safety integrity level (SIL) analysis requirements. If a SIL analysis is not available then the test shall be done at least every 2 years. This test shall confirm operability of the entire system including actuation of the shutdown device at the appropriate design set point and closure of the isolation valves in each tank liquid inlet line.

7.2.3 Emergency shut down system

The correct operation of the emergency shut down system shall be periodically checked.

7.2.4 Emergency shut-down valve(s)

Periodic checks shall be made to ensure that any emergency shut down valves are operating correctly and the valve prevents the flow of product when in the closed position. The test for remotely operated emergency shut down valves shall confirm valve closure from all actuation points. For check valves the test shall confirm the valve's capability to prevent significant liquid back flow through a failed line.

7.2.5 Ancillary equipment

Ancillary equipment other than previously detailed (for example, level gauges and level transmitter, pressure and temperature gauges and transmitters, pressure reducers, vaporisers, etc.) shall be maintained in accordance with manufacturers' recommendations.

7.3 Modifications and change of service

Any proposed modification or change of service shall be formally authorised and documented, for example, by a management of change system, prior to any alteration taking place. Refer to BCGA CP 39 (77) and EIGA Document 51 (63), *Management of change*.

7.4 Decommissioning

When a tank is taken out of service it is good practice to purge with an inert gas; all tanks stored out-of-service should be maintained at a residual positive pressure (≤ 0.5 bar) to prevent moisture ingress.

Appropriate records of the tank's condition i.e. pressure and contents should be maintained.

Prior to reintroduction into service, pressure equipment shall be assessed for its serviceability which may require refurbishment or testing to a documented procedure.

When a tank is to be permanently taken out of service, consideration should be given to making a detailed examination of the inner vessel to assess its condition and, in addition, provide data for revalidation of similar tanks.

For further information on decommissioning, revalidation and the actions to take at the end of service life, refer to BCGA CP 39 (77).

8. TRAINING

All personnel directly involved in the commissioning, operation and maintenance of liquid cryogenic storage systems shall receive suitable information and instruction regarding the hazards associated with cryogenic gases and proper training as applicable to the safe operation and maintenance of the equipment.

It is the duty of the employer to ensure their persons are adequately trained and to establish competency. It is recommended that a training programme is carried out under a formalised system where an acceptable level of competency has to be achieved. Records shall be kept of the training provided and the competence level achieved. The training programme shall make provision for periodic re-training.

Training shall also cover emergency situations, refer to Section 9.

Recommendations for the training of personnel are described in EIGA Document 23 (59), *Safety training of employees*. BCGA GN 23 (83), *Identifying gas safety training requirements in the workplace*, provides information on the topics which should be covered when considering gases safety training.

9. EMERGENCY PLANNING

9.1 Emergency plan

A documented emergency plan shall be prepared by the user to cover foreseeable unplanned incidents involving the installation.

Possible incidents include:

- Uncontrolled cryogenic liquid spillage during product transfer;
- Significant vapour cloud release (not as a result of normal operations);
- Spillage following loss of mechanical integrity of the storage tank or associated systems;
- Uncontrolled release of perlite, refer to Section 3.3.6.
- Fire on the installation, or close to the installation;
- Failure of safety systems, or operation of safety systems;
- Violent impact from external sources, for example, vehicle collision;
- Situations caused by human factors.

The emergency plan should consider:

- The identification of the scales and consequences of potential major incidents, including malicious acts;
- The establishment of the technical and organisational response;
- The identification of the procedures, roles and resources, including the availability of IT equipment and associated software, required to achieve the response;
- The identification of the expertise, arrangements and capabilities required;
- How to co-ordinate and manage the response and resources to an incident, including the establishment of an emergency response team;
- The provision of appropriate training, written guidance and regular practice for an incident.

The emergency plan shall be developed involving, as appropriate, the Local Authority and the emergency services.

The emergency plan will be issued to the emergency response team and shall be readily available in a suitable, easily accessible format.

For general guidance on preparing an emergency plan refer to HSE HSG 191 (29), *Emergency planning for major accidents. Control of Major Accident Hazards Regulations 1999*. Refer also to EIGA Safety Information Human Factors 06 (73), *Organisation. Site emergency response*.

9.2 Emergency procedures

Emergency procedures shall be prepared by the user for the operators and responders. Appropriate training shall be provided.

The procedures shall be readily available to all personnel involved, regularly practised and checked periodically that they are up to date. The procedure shall consider:

- The properties and hazards of cryogenic flammable fluids, these include:
 - Cryogenic burns from the liquid;
 - Flammable gas from the vapour;
 - An oxygen deficient atmosphere in the vapour cloud;
 - Material embrittlement from cryogenic liquids.

NOTES:

1. Flammable gases have different densities, some are lighter than air and will rise into roof spaces, whilst some are heavier than air and will accumulate in low lying areas. Refer to the individual product Safety Data Sheet.

2. Oxygen depletion and flammability checks should be carried out in any area where the liquid gas or the vapour cloud may have entered or accumulated. Particularly in enclosed areas, which includes basements, pits and confined spaces.

- The properties and hazards of perlite, refer to Section 3.3.6;
- Appropriate safety precautions;
- The quantities involved;
- The local topography;
- The emergency equipment required and its availability, including PPE refer to Section 3.3.7;
- The provision of first aid facilities;
- An evacuation plan covering all personnel who are likely to be on site;
- The immediate and any follow-up action to make safe or prevent escalation of the incident, including any requirement for specific sequencing;
- Communications, both on-site and external;
- The co-ordination and management of the response and resources.

9.3 Emergency actions

The following are general emergency actions which should be implemented on all sites and incorporated into the site emergency plan.

The actions to be followed in the event of an incident are to be posted around the installation. Refer to Section 5.4.

The following immediate actions should be taken for all incidents:

- KEEP AWAY, do NOT approach.
- Sound the alarm.
- Protect all persons, evacuate areas affected by the incident.

NOTE: Persons likely to be affected shall know the actions required to minimise the adverse effects of an incident, such as a spillage.

- Contact the emergency response team; this may include contacting the emergency services.
- Establish a hazard zone around the incident and prevent access.
- Follow pre-determined emergency procedures.
- Notify the gas supplier.

NOTE: The gas supplier will be able to provide advice, and will ensure tankers do not come onto site during the incident.

In addition:

In case of leakage / spillage:

- Isolate or repair leaks, if this can be done without risk;
- Allow liquid to evaporate; where available divert towards an area designated as an evaporation area;
- Prevent contact with sources of ignition;
- Use diversions to prevent liquid entering sewers, pits, trenches, basements, pits, confined spaces etc.

In case of fire:

- Consider keeping the tank and associated equipment cool by spraying it with water.

WARNING: When water is used to keep equipment cool careful control must be exercised. Water should not be sprayed near the vent stack outlet(s) due to the potential

danger of plugging vents with ice, and therefore preventing the release of venting gas, refer to Section 4.6.

In case of injury through contact with cryogenic liquid:

- Carry out immediate first aid treatment and seek medical assistance.

NOTES:

1. Information on cold burns resulting from contact with cryogenic liquid and appropriate first aid action is detailed in Appendix 2.
2. HSE L74 (22), *First aid at work. The Health and Safety (First-Aid) Regulations 1981*, provides guidance for employers on providing first aid in the workplace.

10. REFERENCES

1. Planning (Hazardous Substances) Act 1990
2. SI 1990 No. 304 Dangerous Substances (Notification and Marking of Sites) Regulations 1990 (NAMOS).
3. SI 1996 No. 192 The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 (EPS).
4. SI 1996 No. 341 The Health & Safety (Safety Signs and Signals). Regulations 1996.
5. SI 1997 No. 1713 The Confined Spaces Regulations 1997.
6. SI 1998 No. 2306 The Provision and Use of Work Equipment Regulations 1998 (PUWER).
7. SI 1998 No. 2451 Gas Safety (Installation and Use) Regulations 1998
8. SI 1999 No. 2001 The Pressure Equipment Regulations 1999.
9. SI 2000 No. 128 The Pressure Systems Safety Regulations 2000 (PSSR).
10. SI 2002 No. 1144 Personal Protective Equipment Regulations 2002.
11. SI 2002 No. 2677 The Control of Substances Hazardous to Health Regulations 2002 (COSHH).
12. SI 2002 No. 2776 The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR).
13. SI 2005 No. 1541 The Regulatory Reform (Fire Safety) Order 2005.
14. SI 2015 No. 483 The Control of Major Accident Hazards Regulations 2015 (COMAH).

15. SI 2015 No. 627 Planning (Hazardous Substances) Regulations 2015.
16. United Nations Recommendations on the Transport of Dangerous Goods. Model Regulations.
17. European Directive 94/9/EC European Directive on the approximation of the laws of Members States concerning equipment and protective systems intended for use in potentially explosive atmospheres. Also known as 'ATEX 95' or 'the ATEX Equipment Directive'.
18. European Directive 99/92/EC European Directive on minimum requirements for improving the health and safety protection of workers potentially at risk from explosive atmospheres. Also known as 'ATEX 137' or the 'ATEX Workplace Directive'.
19. HSE HSR29 Notification and marking of sites. The Dangerous Substances (Notification and Marking of Sites) Regulations 1990. Guidance on Regulations.
20. HSE L25 Personal Protective Equipment at Work.
21. HSE L64 Safety signs and signals. The Health and Safety (Safety Signs and Signals) guidance on regulations.
22. HSE L74 First aid at work. The Health and Safety (First-Aid) Regulations 1981.
23. HSE L101 Safe work in confined spaces. Confined Spaces Regulations 1997. Approved Code of Practice, Regulations and guidance.
24. HSE L122 Safety of pressure systems. Pressure Systems Safety Regulations 2000. Approved Code of Practice.
25. HSE L138 Dangerous substances and explosive atmospheres. DSEAR 2002. Approved Code of Practice and guidance.
26. HSE Guidance Note GS 4 Safety requirements for pressure testing.
27. HSE Guidance Note GS 6 Avoiding danger from overhead power lines.
28. HSE HSG 47 Avoiding danger from underground services.
29. HSE HSG 191 Emergency planning for major accidents. Control of Major Accident Hazards Regulations 1999.
30. HSE HSG 250 Guidance on permit-to-work systems. A guide for the petroleum, chemical and allied industries.
31. HSE HSG 253 The safe isolation of plant and equipment.

- 32. HSE INDG 258 Confined spaces. A brief guide to working safely.
- 33. BS 476 Fire tests on building materials and structures.
- 34. BS EN 1160 Installations and equipment for liquefied natural gas. General characteristics of liquefied natural gas.
- 35. BS EN 1762 Rubber hoses and hose assemblies for liquefied petroleum gas, LPG (liquid or gaseous phase), and natural gas up to 25 bar (2.5 MPa). Specification.
- 36. BS EN 1991
Part 1-4 Eurocode 1. Actions on structures. General actions. Wind actions.
- 37. BS 4089 Specification for metallic hose assemblies for liquid petroleum gases and liquefied natural gases.
- 38. BS 4250 Specification for commercial butane and commercial propane.
- 39. BS 5266 Emergency lighting. Code of practice for the emergency escape lighting of premises.
- 40. BS 5306
Part 0 Fire protection installations and equipment on premises. Guide for selection of installed systems and other fire equipment.
- 41. BS 5429 Code of Practice for safe operation of small-scale storage facilities for cryogenic liquids.
- 42. BS EN ISO 7010 Graphical symbols. Safety colours and safety signs. Registered safety signs.
- 43. BS 7430 Code of practice for protective earthing of electrical installations.
- 44. BS 7671 Requirements for electrical installations. IET wiring regulations.
- 45. BS EN ISO 10497 Testing of valves. Fire type-testing requirements.
- 46. BS EN 12300 Cryogenic vessels. Cleanliness for cryogenic service.
- 47. BS EN 12434 Cryogenic vessels. Cryogenic flexible hoses.
- 48. BS EN 13458
Part 2 Cryogenic vessels. Static vacuum insulated vessels. Design, fabrication, inspection and testing.
- 49. BS EN 13645 Installations and equipment for liquefied natural gas. Design of onshore installations with a storage capacity between 5 t and 200 t.

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| 50. | BS EN 13648 | Cryogenic vessels. Safety devices for protection against excessive pressure. |
| 51. | BS EN ISO 21009
Part 2 | Cryogenic vessels. Static vacuum insulated vessels. Operational requirements |
| 52. | BS EN 50110
Part 1 | Operation of electrical installations. General requirements. |
| 53. | BS EN 60079
Part 14
Part 29-2 | Explosive atmospheres.
Electrical installations design, selection and erection.
Gas detectors. Selection, installation, use and maintenance of detectors for flammable gases and oxygen. |
| 54. | BS EN 60529 | Specification for degrees of protection provided by enclosures (IP code). |
| 55. | BS EN 62305 | Protection against lightning. |
| 56. | EIGA IGC
Document 06 | Safety in storage, handling and distribution of liquid hydrogen. |
| 57. | EIGA IGC
Document 07 | Metering of cryogenic liquids. |
| 58. | EIGA IGC
Document 15 | Gaseous hydrogen stations. |
| 59. | EIGA IGC
Document 23 | Safety training of employees. |
| 60. | EIGA IGC
Document 24 | Vacuum insulated cryogenic storage tank systems pressure protection devices. |
| 61. | EIGA IGC
Document 40 | Work permit systems. |
| 62. | EIGA IGC
Document 44 | Hazards of inert gases and oxygen depletion. |
| 63. | EIGA IGC
Document 51 | Management of change. |
| 64. | EIGA IGC
Document 63 | Prevention of tow-away incidents. |
| 65. | EIGA IGC
Document 75 | Determination of safety distances. |
| 66. | EIGA IGC
Document 134 | Potentially explosive atmospheres EU Directive 1999/92/EC. |

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| 67. | EIGA IGC
Document 136 | Selection of personal protective equipment. |
| 68. | EIGA IGC
Document 146 | Perlite management. |
| 69. | EIGA IGC
Document 151 | Prevention of excessive pressure during filling of cryogenic vessels. |
| 70. | EIGA IGC
Document 171 | Storage of hydrogen in systems located underground. |
| 71. | EIGA Document
909 | EIGA Cryogenic gases couplings for tanker filling. |
| 72. | EIGA Safety
Information 12 | Task – Human factors in design. |
| 73. | EIGA Safety
Information
Human Factors 06 | Organisation. Site emergency response. |
| 74. | BCGA Code of
Practice 4 | Industrial gas cylinder manifolds and gas distribution pipework (excluding acetylene). |
| 75. | BCGA Code of
Practice 33 | The bulk storage of gaseous hydrogen at users' premises. |
| 76. | BCGA Code of
Practice 36 | Cryogenic liquid storage at users' premises. |
| 77. | BCGA Code of
Practice 39 | In-service requirements of pressure equipment (gas storage and gas distribution systems). |
| 78. | BCGA Code of
Practice 41 | The design, construction, maintenance and operation of filling stations dispensing gaseous fuels. |
| 79. | BCGA Code of
Practice 44 | The storage of gas cylinders. |
| 80. | BCGA Guidance
Note 11 | Reduced oxygen atmospheres. The management of risk associated with reduced oxygen atmospheres resulting from the use of gases in the workplace. |
| 81. | BCGA Guidance
Note 13 | DSEAR Risk Assessment. |
| 82. | BCGA Guidance
Note 17 | BCGA policy and guidance for the safe filling of third-party owned and / or maintained tanks. |

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| 83. | BCGA Guidance Note 23 | Identifying gas safety training requirements in the workplace. |
| 84. | BCGA Leaflet 11 | Safety checks for vacuum insulated storage tanks. |
| 85. | BCGA Leaflet 12 | Liquid gas storage tanks: Your responsibilities. |
| 86. | UKLPG Code of Practice 1 | Bulk LPG storage at fixed installations. |
| 87. | British
Cryoengineering
Society | Cryogenic Safety Manual.

<i>Available through the British Cryogenics Council</i> |
| 88. | British
Cryoengineering
Society | Cryogenics Fluid Databook

<i>Available through the British Cryogenics Council</i> |
| 89. | IGEM UP/20 | Compressed natural gas fuelling stations. |
| 90. | Energy Institute &
APEA | Design, construction, modification, maintenance and decommissioning of filling stations. ‘The Blue Book.’ |

Further information can be obtained from:

UK Legislation	www.legislation.gov.uk
Health and Safety Executive (HSE)	www.hse.gov.uk
British Standards Institute (BSI)	www.bsigroup.co.uk
European Industrial Gases Association (EIGA)	www.eiga.eu
British Compressed Gases Association (BCGA)	www.bcga.co.uk
The British Cryogenics Council (BCC)	http://bcryo.org.uk
Institution of Gas Engineers and Managers (IGEM)	www.igem.org.uk
Liquefied Petroleum Gas Trade Association, UKLPG	www.uklpg.org
The Energy Institute (EI)	www.energyinst.org
The Association for Petroleum and Explosives Administration (APEA)	www.apea.org.uk

HAZARDS FROM ASPHYXIATION

All flammable gases may produce local oxygen-deficient atmospheres, when released in sufficient quantities, which will produce asphyxia if breathed. This is especially true in confined spaces. It should be noted that where cryogenic liquids are used, large volumes of gas are produced from small quantities of liquid as the liquid evaporates.

As a minimum the oxygen concentration in the workplace should be maintained above 19.5 %. Atmospheres containing less than 18 % oxygen are potentially dangerous and entry into such areas shall be prohibited unless appropriate safety controls are adopted.

Asphyxia due to oxygen deficiency is often rapid with no prior warning to the victim. A general indication of what is liable to happen in oxygen deficient atmospheres is given in Table A1-1. It should be appreciated that the reactions of some individuals can be very different from those shown.

O ₂ concentration Volume %	Effects and symptoms
19.5	Minimum safe level of O ₂ (as recommended by HSE).
< 18	Potentially dangerous.
< 10	Risk of unconsciousness followed by brain damage or death due to asphyxia is greatly increased.
< 6	Immediate loss of consciousness occurs.
0	Inhalation of only 2 breaths of any gas containing no oxygen, causes immediate loss of consciousness and death within 2 minutes

Table A1-1: The effects of inhaling reduced concentrations of O₂

A space containing a reduced oxygen atmosphere will meet the criteria of a confined space within the meaning of the Confined Spaces Regulations (5); these regulations require that employers should carry out an adequate risk assessment and put in place appropriate control measures to protect those accessing or working in the area.

Where the risk assessment identifies a potential risk from gases within a confined space, appropriate ventilation systems, gas detection systems and signage warning of the dangers of asphyxiation are required. As part of the confined space risk assessment the assessor shall determine which gases are likely to be present, where the gas may originate from, where the gas may accumulate to and the ventilation available.

Attempts to rescue affected persons from confined spaces or where oxygen deficient atmospheres may be present should only be made by persons trained in the use of breathing apparatus, rescue techniques and confined space entry procedures.

For further information refer to HSE L101 (23), *Safe work in confined spaces. Approved code of practice*, and HSE INDG 258 (32), *Confined spaces. A brief guide to working safely*.

Further details of the hazards of asphyxiation can be found in BCGA GN 11 (80).

FIRST AID TREATMENT OF COLD CONTACT BURNS

The temperature of cryogenic flammable fluids varies. The boiling points, i.e. the temperatures at which the cryogenic flammable fluid vaporises, are detailed in Table A2-1.

Gas	Temperature
Argon	-186 °C
Ethane	-89 °C
Ethylene / Ethene	-104 °C
Helium	-269 °C
Hydrogen	-253 °C
LNG	-161 °C
Methane	-161 °C
Nitrogen	-196 °C
Oxygen	-183 °C

Table A2-1:
Cryogenic flammable fluid temperatures

General effect of extreme cold

The effect of extreme cold on human tissue is to destroy it, a similar end result to that of heat exposure, and in like fashion the amount of cold and the duration of contact is crucial. The destruction of tissue is not so immediately obvious as in the case of burns, since pain is absent in the frozen stage, and the tissue, although rigid, keeps its normal shape and is not obviously destroyed. Pain and destruction becomes more apparent as thawing occurs.

Whilst transient and short exposure produces discomfort in breathing, prolonged inhalation of vapour or cold gas, whether respirable or not, can produce serious effects on the lungs.

Contact with cryogenic liquid or vapour

Liquid, vapour (low-temperature gas) and any uninsulated articles that have been in recent contact with cryogenic liquids can produce effects on human tissue that will vary in severity with temperature and the length of exposure.

Naked or insufficiently protected parts of the body coming into contact with uninsulated articles may stick fast by virtue of the moisture between the two freezing. Flesh may be torn whilst attempting removal.

Protection against cold injuries

Prevent direct contact with cryogenic liquids and with any articles that have been in recent contact with cryogenic liquids.

Correct PPE shall always be worn, refer to Section 3.3.7. The wearing of wet PPE should be avoided.

NOTE: Wet PPE reduces thermal protection and will freeze more extensively.

First Aid treatment

Flush the affected areas of skin with copious quantities of lukewarm water, but do not apply any form of direct heat, for example, hot water, room heaters, etc. Consideration should be given to the provision of a drench type, platform operated, industrial shower, complete with an eye bath in close proximity to the storage tank. The water supply is to be clean and potable. When activated the water flow is to be continuous and should be able to maintain a flow for a minimum of 15 minutes.

All cases of injury involving a cryogenic liquid should be assessed by a qualified medical practitioner. If qualified medical attention is not immediately available, it may be necessary to arrange for the casualty to be transported to hospital.

While waiting for transport:

- (i) Move casualty to a warm place (about 22 °C; (295 K)), out of the wind.
- (ii) Loosen any restrictive clothing.
- (iii) Continue to flush the affected areas of skin with copious quantities of lukewarm water.
- (iv) Once the affected area has returned to normal body temperature protect the affected area from infection, for example, with bulky, dry, sterile dressings. Do not apply too tightly so as to cause restriction of blood circulation.
- (v) Keep the patient calm, warm and at rest.
- (vi) Ensure ambulance crew or hospital is advised of details of the accident and the first aid treatment already administered.
- (vii) Smoking and alcoholic beverages reduce the blood supply to the affected part and should be avoided.

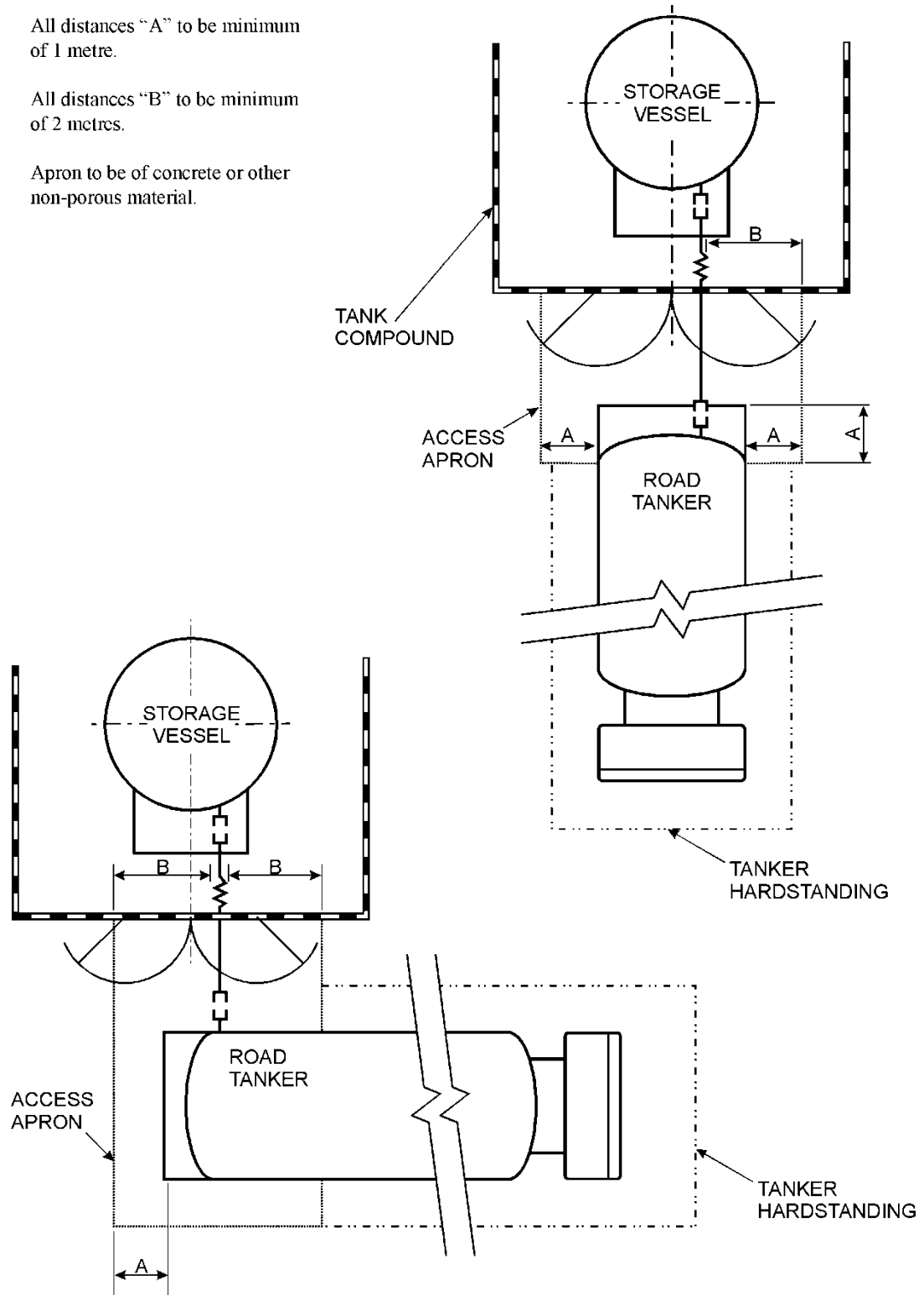
NOTES:

1. Further information on providing first aid treatment for cold contact burns is available in the British Cryoengineering Society, *Cryogenics Safety Manual* (87).
2. HSE L74 (22) provides guidance for employers on providing first aid in the workplace.

PLAN VIEW OF LIQUID TRANSFER AREA,

ACCESS APRON AND TANKER STANDING AREA







1. All distances "A" to be minimum of 1 metre.
2. All distances "B" to be minimum of 2 metres.
3. Apron to be of concrete or other non-porous material.








MINIMUM RECOMMENDED SEPARATION DISTANCES

Refer to Section 4.4.

The following descriptors are used in the separation distance table, with examples of the potential hazards.

Image	Descriptors	Hazard
	Compressor, ventilator and air conditioning intakes.	Compressor – Ignition of leaking product. Ventilator and air conditioning intakes – flammable atmosphere from leaking product, increased fire risk and danger to personnel. Embrittlement of equipment.
	Fuel gas vent pipes.	Ignition of leaking product. Thermal radiation from fire.
	Offices, canteens and escape routes from buildings and other areas where employees and visitors are likely to congregate.	Oxygen deficient atmosphere from leaking product, danger to personnel. Flammable atmosphere from leaking product, increased fire risk. Thermal radiation from fire.
	Railway Lines.	Flammable atmosphere from leaking product, increased fire risk. Ignition of leaking product. Thermal radiation from fire. Embrittlement of equipment. Reduced visibility from major product release.
	Public roads.	Flammable atmosphere from leaking product, increased fire risk. Ignition of leaking product. Thermal radiation from fire. Embrittlement of equipment. Reduced visibility from major product release.
	Property boundaries	Flammable atmosphere from leaking product, increased fire risk. Ignition of leaking product. Thermal radiation from fire. Embrittlement of equipment. Reduced visibility from major product release. Oxygen deficient atmosphere from leaking product, danger to personnel.

	<p>Vehicle parking areas.</p>	<p>Ventilator and air conditioning intakes – flammable atmosphere from leaking product, increased fire risk, danger to personnel. Ignition of leaking product. Oxygen deficient atmosphere from leaking product, danger to personnel. Embrittlement of equipment. Reduced visibility from major product release. Accessibility to the tank controls.</p>
	<p>Pits, ducts & surface water drains (untrapped). Openings of systems below ground level.</p>	<p>Ignition of leaking product. Oxygen deficient atmosphere from leaking product, danger to personnel. Flammable atmosphere from leaking product, increased fire risk.</p>
	<p>Bulk flammable fluids.</p>	<p>Ignition from leaking product. Thermal radiation from fire. Embrittlement of equipment.</p>
	<p>Stocks of combustible material, site huts, wooden structures etc.</p>	<p>Thermal radiation from fire.</p>
	<p>Areas where open flames, smoking etc are permitted.</p>	<p>Ignition from leaking product. Flammable atmosphere from leaking product, increased fire risk. Oxygen deficient atmosphere from leaking product, increased fire risk, danger to personnel.</p>
	<p>Electrical cable and pylons</p>	<p>Flammable atmosphere from leaking product, increased fire risk.</p>

MINIMUM RECOMMENDED SEPARATION DISTANCES

Minimum recommended separation distances continue to be revised as experience is gained and improved computer based methodologies are further developed.

The table below is based on information within BS EN ISO 21009 Part 2 (51). Currently this provides the latest published distances and is in-line with previous BCGA recommendations.

For larger volumes / masses of products in the vessel, separation distances are determined by a specific risk assessment.

Where a specific risk assessment is required, or if there is any doubt over a specific distance then that distance should be determined by risk assessment. EIGA provide a methodology within EIGA Document 75 (65). BS EN 13645 (49) provides a methodology for LNG storage installations.

TABLE A4-1 – Minimum recommended separation distances (Distance in metres).

Descriptor	LH ₂	Other Flammable Fluids	
	≤ 5 tonnes	≤ 50 tonnes	
Compressor, ventilator and air conditioning intakes.	15	5	
Fuel gas vent pipes.	15	5	
Offices, canteens and escape routes from buildings and other areas where employees and visitors are likely to congregate.	15	5	
Railway Lines.	8	5	
Public roads.	8	5	
Property boundaries.	8	5	
Vehicle parking areas.	8	5	
Pits, ducts & surface water drains (untrapped). Openings of systems below ground level.	8	5	
Bulk flammable fluids, for tanks containing dissimilar product. NOTE 2.	8	5	
Stocks of solid combustible material, site huts, wooden structures etc.	8	5	
Areas where open flames, smoking etc. are permitted.	8	5	
Electrical cable and pylons.	< 1 kV	1.5	1.5
	≥ 1 kV	10	10
	Not to be located directly underneath. Includes telephone cables.		

TABLE A4-2 - Minimum recommended separation distances between flammable storage tanks and other specific hazards

Tanks and other hazards	Minimum separation distance
Between storage tanks containing identical flammable gases and operating as part of a combined storage scheme.	NOTE 2 1.5 m
Between storage tanks for flammable gases and storage tanks for other hazards.	Liquid O ₂ = 7.5 m Flammable solid = 10 m Flammable liquid = 10 m

NOTES:

1. The separation distance between tanks is also to allow pedestrian access around the whole tank circumference, and to allow maintenance activities to take place, including sufficient space for maintenance equipment, for example, cranes, ladders etc.
2. Where tanks are close together, the location of tank vents, and the direction of the vent exhaust shall be assessed. Venting gas can cause mechanical damage if allowed to impact on adjacent tanks or their associated equipment. Where venting gas may impact on adjacent tanks greater separation distances are required.
3. Where protective structures such as fire walls are installed, the following limits apply:
 - To minimise the consequence of an accidental leakage, the vessel should not be enveloped or constricted by walls or buildings.
 - If the vessel is installed in close proximity to a building or a fire resistant wall, the minimum distance of 2.5 m should apply.
 - Further walls (vessel in 2 or 3 sided zone) should be avoided as much as possible to prevent accidental gas confinement, if leakage occurs.
 - If proximity to more than one wall cannot be avoided, the above safety distances should be increased, or the wall structure should be strengthened to withstand an increased overpressure.



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