BCGA CODE OF PRACTICE CP 20

BULK LIQUID OXYGEN STORAGE AT PRODUCTION SITES

Revision 2 : 2002

British Compressed Gases Association

BCGA CODE OF PRACTICE CP 20

BULK LIQUID OXYGEN STORAGE AT PRODUCTION SITES

Revision 2 : 2002

BRITISH COMPRESSED GASES ASSOCIATION
4a Mallard Way, Pride Park, Derby,
DE24 8GX
Tel 01332 225120
Website : www.bcga.co.uk

ISSN 0260-4809

PREFACE

The various publications issued by the British Compressed Gases Association have the objective of establishing consistency in design, construction practices and user operational and maintenance procedures, in order to establish high standards of reliability and safety in the interests of employers, employees and the general public.

The Association endeavours to compile these documents using the best sources of information known at the date of issue. The information is used in good faith and belief in its accuracy. The publications are intended for use by technically competent persons and their application does not, therefore, remove the need for technical and managerial judgement in practical situations and with due regard to local circumstances, nor do they confer any immunity or exemption from relevant legal requirements, including by-laws.

The onus of responsibility for their application lies with the user. The Association, its officers, its members and individual members of any Working Parties can accept no legal liability or responsibility whatsoever, howsoever arising, for the consequences of the use or misuse of the publications.

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. The intention of BCGA is that this document should be read and used in the context of these references where the subjects have a bearing on the local application of the processes or operations carried out by the user.

BCGA's publications are reviewed, and revised if necessary, at three-yearly intervals. Readers are advised to check the list of publications on the Association's website www.bcga.co.uk to ensure that the copy in their possession is the current version.

CONTENTS

Section			**Page**

TERMINOLOGY & DEFINITIONS

1. **Shall**: Indicates a mandatory requirement for compliance with this Code of Practice.

2. **Should**: Indicates a preferred requirement but is not mandatory for compliance with this Code of Practice.

3. **May**: Indicates an option available to the user of this Code of Practice.

4. **Tank**: Indicates an assembly, complete with a piping system, of an inner vessel and an outer jacket to contain insulation. The insulation space may be at atmospheric pressure, slightly above atmospheric pressure or subject to a vacuum. See Appendix 1.

5. **Vessel**: Indicates a pressure vessel which may or may not be insulated.

6. **Outer Jacket**: Indicates a shell surrounding an inner vessel, the interspace containing an insulating system e.g. vacuum, granular or fibrous insulant.

7. **Access Apron**: Indicates an area between the tank and a tanker where the process operating controls on both tank and tanker are accessible to the operator during filling/discharging. This area will normally have provision for diverting any liquid spillage.

8. **Liquid Transfer Area**: Indicates an area adjacent to the tank which surrounds the tanker, when the latter is in the filling/discharging position, and which includes the access apron.

9. **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.

10. **Examination**: Means examination in accordance with the Written Scheme of Examination as detailed in the Pressure Systems Safety Regulations 2000 (27).

11. **Production Site**: Is typically where liquid oxygen is produced from an air separation unit and stored on site.

12. Numerals in brackets refer to References (Section 7).

INTRODUCTION

In 1985 the Industrial Gases Committee (IGC) of the Commission Permanente Internationale (CPI) published a document (reference 21/85/E (1)) entitled “Bulk Liquid Oxygen Storage at Production Sites”.

The British Compressed Gases Association (BCGA) has recognised the need to produce an equivalent Document specifically for the United Kingdom.

This BCGA Document is intended as a Code of Practice for the guidance of UK companies directly associated with the design, operation and maintenance of bulk liquid oxygen storage installations. The objective of this Code of Practice is to make reference, where applicable, to UK legislation and British Standards where these apply to liquid oxygen (LOX) systems and to take into account the specific practices of the UK industrial gas companies, particularly in relation to safety distances.

It is recognised that sites operated by industrial gas producers have a level of expertise and specialist knowledge that is not available to general industrial and other users.

This Code of Practice also supersedes the BOC Ltd/Air Products Ltd joint document “Code of Practice for the Bulk Storage of Liquid Oxygen at Production Sites” (April 1974 (2)) which was published in conjunction with HM Factories Inspectorate.

This Code of Practice is based generally on the IGC Document, but in some instances gives more detailed requirements for the UK.

The BCGA is grateful for the active help and co-operation of the Health and Safety Executive who provided much valuable data which was used as the basis for Section 2 of this document, and who also provided comments on much of the text.

With the permission of the IGC, sections of the IGC Document have also been duplicated.

The BCGA wishes to acknowledge the work of the IGC committee which prepared Document 21/85/E.

The increase in recent years in the size of production capacity of Air Separation Plants has lead to a corresponding increase in the capacity of liquid oxygen storage installations at production sites. It has therefore become more important to consider at the design stage the potential hazards associated with liquid oxygen, the consequence and effects on the local environment of a major release of liquid, and the preventative measures required.

All new storage installations on production sites shall comply with this Code of Practice. Major modifications for existing production plant LOX storage should also comply with this Code of Practice, but it is not intended to apply retrospectively to existing production site storage installations.

SCOPE

A bulk liquid oxygen storage installation on a production site is defined, for the purposes of this Code of Practice, as the total fixed assembly of liquid storage tank(s) and other equipment such as pumps, controls and ancillary equipment required to discharge from the storage into pipelines or to transfer liquid to or from road vehicles. The installation also includes the liquid transfer area for road vehicles. The facilities for filling rail vehicles are not specifically covered in this Code of Practice, although the provisions of this Code of Practice generally apply to the liquid storage part of the rail fill installation.

This Code of Practice covers LOX storage installations on production sites where the storage installation is connected to the production process plant. Individual vessel capacity for such storage is normally greater than 200 tonnes of liquid oxygen. However, where the individual vessel capacity is less than 200 tonnes but the storage installation is connected to the production process the installation shall also comply with this Code of Practice.

The process systems of the production plant (such as compressors, heat exchangers, distillation columns and turbo expanders) are specifically excluded from the scope of this Code of Practice, as are gaseous distribution pipelines and related equipment.

The liquid feed pipeline from the plant into the LOX storage tank shall be considered as part of the production plant.

For the purposes of this Code of Practice, cluster tanks (i.e. multiple inner vessels in a single outer jacket) are considered as a single tank whose capacity is the sum of the capacities of the individual inner vessels. Where the storage contains multiple products (for example oxygen and nitrogen or argon in the same cluster tank) the relevant BCGA Code of Practice for oxygen storage shall apply to the installation, as judged on the sum of all the oxygen vessel capacities. (See Appendix 1).

Pumping systems often form part of the liquid oxygen storage installation. It is recognised that the design and installation of these pump systems is a complex subject. No detailed recommendations are given in this Code of Practice but due consideration should be given to:

- the accepted principles of good practice for oxygen service
- the prevention of mal-operation of the pump(s)
- siting the pump(s) to provide personnel protection in the event of an oxygen pump fire
- the use of fire containment shields
- adequate inspection and maintenance procedures.

For centrifugal liquid oxygen pumps, reference should be made to IGC Document 11/82/E "Code of Practice for the design and operation of centrifugal liquid oxygen pumps" (3).

Where a LOX storage installation on a production site has an individual vessel capacity of less than 200 tonnes and the storage is not connected to the production process, BCGA Code of Practice CP 19 "Bulk Liquid Oxygen Storage at Users' Premises" (4) may be applied to this installation.

At cylinder filling depots operated by oxygen suppliers, the oxygen storage vessel capacity is normally less than 200 tonnes. In such cases this Code of Practice on LOX storage on production sites should only apply when the tank is connected to an oxygen manufacturing plant. However the provisions in BCGA Code of Practice on Bulk Liquid Oxygen Storage at Users' Premises CP 19 (4) in relation to safety distances, periodic inspection and testing and the liquid transfer area may be applied to such cylinder filling depots.

1. GENERAL DESIGN CONSIDERATIONS

1.1 Properties of Oxygen

Gaseous oxygen is colourless, odourless and tasteless: it is non toxic; it is slightly heavier than air. It is not flammable but vigorously supports combustion.

Breathing pure oxygen at atmospheric pressure is not dangerous although exposure for several hours may cause temporary functional disorder to the lungs.

Oxygen content in air	Vol %	21
Gas density at 1.013 bar, 15°C	kg/m³	1.36
Boiling temperature at 1.013 bar	°C	-183
Liquid density at 1.013 bar, -183°C	kg/l	1.14

One litre of liquid oxygen gives approximately 850 litres of gas at ambient conditions.

Cold gaseous oxygen is substantially heavier than air and may accumulate in pits and trenches.

1.2 Precautions

1.2.1 Oxygen Enrichment of the Atmosphere

The atmosphere normally contains 21% by volume of oxygen. Enrichment to only 23.5% may give rise to a significant increase in the rate of combustion of burning materials exposed to such an atmosphere.

Many materials, including some common metals, which are not flammable in air, may burn in oxygen enriched atmospheres when ignited.

Hazards from oxygen enrichment are further explained in Appendix 2. Good ventilation shall always be provided in areas where liquid oxygen is stored or transferred.

1.2.2 Oil, Grease, Combustible Material and Other Foreign Matter

Most oils, greases and organic materials constitute a fire or explosion hazard in oxygen enriched atmospheres and shall not be used on equipment, which is intended for oxygen service. Only materials acceptable for the particular oxygen service application may be used.

All equipment for oxygen service shall be specifically designed and prepared.

1.2.3 Cleaning for Oxygen Service

Before putting equipment into service with oxygen, either for the first time or following maintenance, it is essential that all surfaces which may come into contact with an oxygen enriched environment are "clean for oxygen service", which means: dry and free from any loose or virtually loose constituents, such as slag, rust, weld residues, blasting materials (shot or grit), and free from hydrocarbons or other materials incompatible with oxygen. For hydrocarbon contamination of industrial oxygen systems, a maximum limit of 500 milligrams per square metre of cleaned surface area is acceptable. Advice on the cleaning for oxygen systems is given in the following documents:

"Cleaning of Equipment for Oxygen Service - Guidelines" prepared by IGC (5) gives practical guidance on how to prepare equipment for oxygen service.

BS 6869 gives procedures for ensuring the cleanliness of industrial process, measurement and control equipment for oxygen service (37).

BS EN 12300 gives information on ensuring cleanliness of vessels for cryogenic service generally (34).

BCGA Technical Report TR3 (11) gives information about cleaning oxygen system components without the use of chemical solvents.

The maintenance and assembly of equipment for oxygen service shall be carried out in clean, oil free conditions. All tools and protective clothing (such as overalls, gloves and footwear) shall be clean and free of grease and oil. Where gloves are not used, clean hands are essential.

Degreasing of an installation or parts of it demands the use of a degreasing agent, which satisfies the following requirements:

- No or slow reaction with oxygen.
- Preferably no or low toxicity.
- Vapour pressure near to atmospheric pressure to keep boil-off vapours to a minimum.
- Compatible with both materials of installation and materials used to apply degreasing agent, e.g. hoses, etc.

It is important that all traces of degreasing agents are removed from the system prior to commissioning with oxygen. Some agents, such as halogenated solvents, may be non-flammable in air, but can explode in oxygen-enriched atmospheres, or in liquid oxygen.

Good housekeeping is necessary to prevent contamination by loose debris or combustibles.

1.2.4 Embrittlement of Materials

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

Metals suitable for liquid oxygen service are 9% nickel steel, 18/8 stainless steel and other austenitic stainless steels, copper and its alloys and aluminium alloys. PTFE (polytetrafluoroethylene) is the most widely used plastics material for sealing purposes in liquid oxygen service but other reinforced plastics are also used. For further information on materials see BS 5429 (6).

1.2.5 Cryogenic Burns

Severe damage to the skin may be caused by contact with liquid oxygen, cold gaseous oxygen or with non-insulated pipes or receptacles containing liquid oxygen. For this reason, gloves and eye protection shall be worn when handling equipment in liquid or gaseous oxygen service.

All the safety aspects of handling cryogenic liquid oxygen cannot be covered adequately in this Code of Practice. The reader is therefore referred to the British Cryoengineering Society publication, "Cryogenics Safety Manual" (7) for further information.

1.2.6 Fire Fighting System

First aid fire fighting equipment comprising water hose reels and/or dry powder extinguishers shall be available near a liquid oxygen storage installation. The type and quantity of the fire fighting equipment depends on the size of the installation and should be discussed with the fire authorities.

1.2.7 Hot Work

No hot work shall be performed in the vicinity of the installation without a Permit to Work. (See 6.2).

1.2.8 Ignition Sources

Smoking and open fires shall be prohibited within the minimum distances specified in Section 2 of this Code of Practice.

For electrical equipment, see 1.4.6.

1.2.9 Insulation Materials

The components used in an insulating system shall be such that the finished insulation is suitable for oxygen service.

1.2.10 Means of Escape

Installations covered by this Code of Practice storing or having facilities to store greater than 135 tonnes of liquid oxygen require a Fire Certificate under the provisions of the Fire Certificates (Special Premises) Regulations 1976 (8) which are enforced by HSE. The Fire Certificate deals with means of escape in case of fire, fire warning systems, fire training and similar general fire precautions matters.

1.3 Regulations and Codes

This Code of Practice describes minimum requirements. All relevant statutory regulations shall be applied and relevant codes of practice, standards and specifications shall be taken into account in the designs and installations covered by this Code of Practice. (See reference list in Section 7).

In certain circumstances liquid oxygen installations will be subject to the Notification of Installations Handling Hazardous Substances Regulations 1982 (NIHHS) (9) and the Control of Major Accident Hazards Regulations 1999 (COMAH) (10).

NIHHS applies where the ‘notifiable quantity’ of the relevant substance is 500 tonnes or more. The ‘notifiable quantity’ includes the amount of the substance liable to be in storage, in transport on site, in use for the purposes of manufacturing or processing and in pipelines within 500 m of the site.

Notification shall be sent to the HSE at least three months before commencing the activity.

The COMAH Regulations require that persons in control of an industrial activity subject to the Regulations shall at any time be able to demonstrate that the activity is being operated safely. They place an obligation on such persons to report major accidents (Regulations 4 and 5).

More stringent requirements contained in regulations 7 to 12 (known as ‘top-tier’ requirements), which apply to only the potentially more hazardous activities, call for the following:

- A safety report to be sent to the HSE at least three months before commencement of the activity.

- The preparation of an on-site emergency plan before commencement of the activity

- Provision of information to the Local Authority (at county or equivalent level), to enable them to prepare an off-site emergency plan

- Distribution of safety information to the public before commencement of the activity.

The top-tier requirements of COMAH apply to industrial installations carrying out a processing operation involving 2,000 tonnes or more of liquid oxygen. In assessing the 2,000 tonnes, account should be taken of the liquid oxygen in on-site storage and on-site transport associated with the process operation as well as of the quantity in the process itself.

Appendix 5 summarises the quantities of liquid oxygen stored in relation to legislation.

1.4 Design of Installation

1.4.1 Design and Manufacture of the Tank

Tanks shall be designed, manufactured and installed in accordance with recognised pressure vessel, storage tank and piping codes (e.g. PD 5500 (12)/ BS 7777 Part 4 (13)/ANSI/ASME B31.3 (14)) and shall comply with the production site operator's specifications. Consideration shall be given to the requirements of The Pressure Equipment Regulations (38) where appropriate.

Tanks shall be designed to withstand wind-loads in accordance with the appropriate design codes and with BS 6399 Part 2 1997 (15).

1.4.2 Tank Inspection (During Manufacture)

Pressure vessels and storage tanks shall be inspected and approved during manufacture by a Competent Person.

Butt welds in the inner vessel shall be radiographed in accordance with the design code.

If required, prior to its first use, a Competent Person shall certify the vessel as suitable for the duty within defined operating limits for a defined period.

Any modification to the system shall be carried out in accordance with the applicable design code; some modifications may require consultation with the vessel supplier.

1.4.3 Pressure Relief Devices

Pressure relief devices shall be provided to prevent over pressure of the inner vessel. The devices shall be suitable for the prevailing environmental conditions.

For the protection of the inner vessel a minimum of two independent pressure relief devices shall be provided. The capacity of each device shall be such that should one malfunction or be removed for maintenance; the vessel shall be adequately protected. Both pressure relief devices will normally be in service.

Consideration shall be given to the design of the system to allow isolation of individual pressure relief devices to facilitate their periodic testing or replacement.

Methods of isolation are commonly a three-way valve or isolation valve upstream of each relief device. The system installed shall ensure that the tank is fully protected at all times.

Three way valves shall be provided with a position indicator showing which relief devices are on line.

The design relieving capacity of the inner vessel pressure relief system shall include the worst foreseeable combination of the operational and upset conditions, e.g.:

- Boil-off rate including loss of vacuum where applicable.
- Flash gas from plant make, from road tankers and pumps recycling product.
- Malfunction of control valves in pressure raising systems.
- Barometric pressure changes.

The pipes and valves connecting the vessel to pressure relief devices and the vent piping shall be adequately sized for the flow conditions in accordance with a relevant code. Excess pressure drop in the upstream system can lead to relief valve chattering causing reduction in capacity and valve damage.

Vent pipes shall be correctly supported and designed to prevent blockage by ice and other foreign matter.

Thermal relief devices shall be provided to prevent overpressure in systems where liquid or cold gas can be trapped.

Relief valves shall be in accordance with a recognised standard, e.g. BS 6759 (16).

Where bursting discs are installed, they shall be in accordance with a recognised standard, e.g. BS 2915 (17).

Pressure relief devices shall be provided to prevent over-pressure of the outer jacket.

The devices shall be suitable for the prevailing environmental conditions.

1.4.4 Under-pressure Prevention Devices

Where necessary, the inner vessel shall be equipped with under-pressure (vacuum) prevention devices to prevent collapse of the vessel by the development of partial vacuum conditions in the vessel.

Partial vacuum conditions can arise due to excessive liquid withdrawal rates, by introducing super-cooled product into a partially filled inner vessel or, under certain conditions, sudden increases in atmospheric pressure. To avoid partial vacuum conditions, correct operating procedures shall be introduced and periodic checks made to ensure the under-pressure prevention device is in working order.

Frequent demands on the vacuum relief valve may give rise to ingress of excessive quantities of moist air resulting in accumulation of ice and subsequent blockage of the relief valve piping. Pressure raising coils should be appropriately sized to prevent regular operation of vacuum relief valves.

1.4.5 Pits

Equipment requiring regular attention or maintenance should not be installed in pits. Flanged joints and similar sources of potential leakage should also be avoided in pits. Where pits cannot be avoided, notices shall be positioned, warning of the hazards of oxygen enrichment and calling as a minimum, for analysis of the pit atmosphere and an entry permit in writing, to ensure that it is safe to enter. For further information on oxygen enrichment see IGC document 04/93/E(18). As a minimum, procedures shall comply with the requirements of the Confined Spaces Regulations 1997 (19).

1.4.6 Electrical Equipment

Flameproof, explosion proof or other forms of classified electrical equipment are not necessary for oxygen systems since oxygen is not classified as a flammable gas according to BS EN 60079 Part 14 (20).

Electrical equipment necessary for the installation and installed within the distance for source of ignition in Section 2 shall be to BSEN 60529(39), protection class IP 54 or better. For more severe environmental conditions IP 55 (designed to protect against jets of water) or IP 65 (designed to eliminate dust and protect against water jets) should be used. Consideration should be given to earth bonding of the installation pipework. All electrical installation shall comply with current electrical legislation.

1.4.7 Couplings

Couplings used for the transfer of liquid oxygen shall be non-interchangeable with those used for other products.

1.4.8 Lighting

Lighting shall be provided of adequate intensity for all working areas so that at all times operations can be carried out safely. The need for emergency lighting shall be considered.

1.4.9 Pipework

The pipework shall be marked to identify the product transported. Valves shall be marked for function where appropriate.

1.4.10 Control and Instrumentation

The installation shall have the following features:

a) Two independent means of indicating high liquid level.
b) Automatic pressure make up.
c) Automatic pressure vent.
d) Pressure indication.
e) High and low pressure alarms.
f) High liquid level alarm.
g) Remote means of shutting off liquid supply into the tank.

1.4.11 Outer Jacket Purge

Non-vacuum insulated jackets shall be provided with a dry nitrogen purge system to ensure that a positive pressure is maintained at all times and that the insulation is kept dry and free from ice.

2. LAYOUT OF THE INSTALLATION

2.1 General

The best guarantee for safe operation and prevention of dangerous leakage is the strict adherence to nationally accepted design and construction codes for storage installations and to specific routine operating instructions.

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

An installation may, because of its size or strategic location, come within the scope of specific legislation for planning controls. The siting of any such proposed installation shall be discussed and agreed with the local authority and the appropriate sections of the Health and Safety Executive.

2.2 Safety Distances

2.2.1 Basis

The safety distances given in Appendix 6 are based on experience and calculations of minor releases and are not intended to protect against catastrophic failure of the liquid storage vessel. This philosophy is supported by previous operating history.

2.2.2 Definitions and Intentions

Safety distances are defined as the distance from the exposure to:

a) Any point on the storage system where in normal operation oxygen leakage or spillages can occur (eg hose couplings, relief valve vents, etc.), or

b) The tank outer jacket, or

c) The tank nozzle or fill connections

whichever gives the greater distance to the storage tank.

Safety distances are intended to:

a) Protect personnel from exposure to oxygen enriched atmosphere or cryogenic burns (see also Appendix 3) and to prevent fire enhancement in the event of the release of liquid oxygen, and

b) Protect the installation from the effect of thermal radiation or jet flame impingement from fire hazards.

These distances are based on the oxygen storage pressure, ground roughness, likely weather conditions and an assumed vapour cloud release rate from the maximum diameter of liquid phase pipework on the storage installation and take into account site topography and provision for containment or diversion of the liquid spillage.

The safety distances quoted are based on calculations provided by the Health & Safety Executive using SRD programme CRUNCH.

2.2.3 On-Site Risks

The safety distances given in Appendix 6 Figure 1 are intended to protect storage installations, together with personnel and the environment within the site boundary, in conjunction with the following precautions:

- Taking into account topography, containment or diversion of spillage
- Careful siting of storage to allow for likely movement of vapour clouds
- Provision of emergency isolation valves
- Implementation of emergency procedures
- Adequate personnel training.

These distances are the minimum required to give adequate protection against risks involved in the normal operation of LOX storage installations and shall be observed. It is recognised that it is not reasonably practicable to define safety distances, which **alone** give adequate protection in the event of a **continuous** release of liquid oxygen from storage installations.

The distances indicated in Appendix 6 correspond to well-established practice resulting from 485,000 tank years of service (2000). Should any evidence become available which indicates that a revision of the safety distances, in this document, is necessary then such a revision will take place.

Table 1, Table 2 and Table 3 of Appendix 6 may be used for safety distances both within and outside the site boundary.

2.2.4 Off-Site Risks

To enable the site operator to minimise the risk to the general public and the environment, it is necessary for each of the likely risks and exposures to be considered individually, taking into account the package of precautions provided within the site boundary but recognising that on-site emergency procedures and personnel training cannot normally be applied outside the site.

Prior to installation of the liquid oxygen storage, the site operator shall provide proposed separation distance figures to the Health & Safety Executive.

2.3 Location of Installation

2.3.1 Outdoor Installation

All LOX storage installations at production sites shall be situated in the open air in a well-ventilated position. LOX installations shall not be located inside buildings.

2.3.2 Protection Against Electrical Hazards

The location shall be chosen so that damage to the installation by electric arcing from overhead or other cables cannot occur. The storage tank(s) shall be protected against lightning discharge. BS 6651 (21) should be referred to for guidance on lightning protection.

2.3.3 Level & Slope

The slope of the ground shall be such as to provide normal surface water drainage, but shall also take into consideration the prevention of directing hazardous materials, such as oil, towards the oxygen installation. An oxygen spillage shall not be directed towards hazardous materials or locations where people are at risk. Where liquid oxygen storage tanks are required to be installed at an elevated level, they shall be supported by purpose-designed structures. Consideration should be given to protecting these structures from cryogenic spillage.

2.3.4 Position of Oxygen Vents

All oxygen vents including those from relief devices shall be directed so as to avoid the risk of impingement on personnel, buildings, structural steelwork or any combustible materials. For the separation distance from fuel gas vents see Appendix 6, Figure 1.

2.3.5 Vapour Clouds

All cryogenic liquid spillages produce vapour clouds, which are visible. Tests and calculations show that the extremities of the visible cloud are non-hazardous.

When siting the installation, due consideration shall be given to the possibility of the movement of vapour clouds, originating from spillage or venting, which could be a hazard (decreased visibility, oxygen enrichment). Local wind conditions and the topography shall be taken into account.

Vapour clouds from releases are generally low lying (typically below waist height). Such vapour clouds may be quite extensive depending on weather conditions and persons working below ground or at low level in the vicinity may be at risk. Guidance on emergency procedures is given in Section 6.4.

Further guidance can be obtained from BCGA documents TR1 “A Method for Estimating the Off-Site Risks from Bulk Storage of Liquefied Oxygen R1(LOX)” (22) and TR2 “The Probability of Fatality in Oxygen Enriched Atmospheres due to Spillage of Liquid Oxygen R2(LOX)” (35).

2.3.6 Diversion of Spillage

The maximum total liquid spillage which may occur due to failures of associated equipment, other than the main storage tank itself, shall be determined by reference to the equipment and system of working in use at the installation.

Provision shall be made to contain the maximum liquid spillage or divert it towards the safest available area.

The fire-fighting system noted in paragraph 1.2.6 may be used for diverting a vapour cloud or liquid spillage.

2.3.7 Protection of Other Areas

The site layout shall provide protection from liquid oxygen spillage for vulnerable areas, such as places where people may congregate, steel structures and other foundations. This protection may be achieved by the slope of the ground, provision of kerbs, gulleys or barriers of adequate size.

Drainage systems within the distance specified in Appendix 6 shall be provided with traps to prevent the ingress of liquid or gaseous oxygen. Un-trapped drainage systems shall be at least the distance specified in Appendix 6, Figure 1 from the LOX installation.

2.4 Liquid Transfer Area

2.4.1 Location of Area

A road tanker, when in position for filling from or discharging to the installation, shall be in the open air and not be in a walled enclosure from which the escape of liquid or heavy vapour is restricted. Tankers should have easy access to and from the installation at all times. Kerbs or barriers shall be provided to prevent damage to any part of the installation by the tanker or other vehicles.

2.4.2 Construction of Access Apron

The access apron is defined on page 1 and shall be constructed and laid out generally in accordance with Appendix 4. The materials used shall be suitable for use with oxygen e.g. gravel, concrete, ceramic blocks etc. Asphalt or hydrocarbon based products shall not be used. The tanker hard-standing is not normally regarded as part of the access apron.

2.4.3 Control of Tanker Operation

Operating personnel shall have unobstructed freedom of movement between the tanker and valve controls on the installation at all times.

All tankers shall be provided with a positive means of preventing tow-away accidents. Such devices shall be 'fail-safe' in operation and regular checks on the operation of such devices shall be included in maintenance procedures. Operating procedures shall be written to take account of such means.

Reference should be made to the Carriage of Dangerous Goods by Road Regulations 1996 (23). The vessel shall be adequately protected against over-pressure from the road tanker Reference EIGA publication 59/98 (36).

2.5 Liquid Transfer Pumps

Ground mounted pumps for the transfer of liquid oxygen from or to the storage tank shall be designed and installed in accordance with the IGC Document 11/82/E "Code of Practice for the Design and Operation of Centrifugal Liquid Oxygen Pumps" (3).

This IGC Code of Practice classifies pumps as either high or low duty depending on design conditions. High duty pumps are designed to operate under more severe conditions than those for low duty pumps. Fire protection shield(s) shall be provided adjacent to or around high duty pumps to minimise the potential hazard to personnel and equipment.

It is not necessary to provide fire protection shields adjacent to or around low duty pumps.

2.6 Isolation Valves

2.6.1 Emergency Isolation Valves

All bulk storage tanks of 200 tonnes capacity and above, fitted with liquid withdrawal or pump suction lines of 50mm bore or greater, shall be provided with an emergency isolation valve. They may be located internally or outside the tank. Internal location should be applied wherever possible. If externally located it should be as close as possible to the tank, to prevent the bulk flow of liquid from the vessel, in the event of a line failure downstream of this valve.

The emergency isolation valve is additional to the normal isolating valve required for process operation. The emergency isolation valve shall be reliable and quick acting and shall be capable of operation under conditions of heavy liquid spillage. The valve shall fail safe in a closed position on failure of operating power or operating fluid supply. Provision shall be made for operation from relatively safe point(s) remote from the potential area of flow of leaking liquid. The locations of the operating points, their purpose and mode of operation shall be clearly indicated by suitable notices.

Where it is judged that the presence of a liquid pump(s) or other equipment constitutes a hazard, action shall be taken to protect the emergency valve and its actuator from the consequences of fire.

2.6.2 Secondary Isolation Valves

All bulk storage vessels for LOX shall be provided with at least two independent means of isolating the liquid withdrawal or pump suction pipelines. This can include emergency isolation valves, provided they are designed for tight shut off, and process isolation valves as specified below.

2.6.3 Process Isolation Valves

Any primary process isolation valve shall be located as close as practical to the vessel itself, but downstream of any emergency isolation valves. The position of isolation valves shall be such that they are subject to an acceptable low risk from damage from external sources. Protection against overpressure must be installed between any two isolation valves where liquid or cold vapour can be trapped.

2.7 Foundations

The tank foundation shall be designed to safely withstand the weight of the tank, its contents and other possible loads resulting from wind, snow, water content during pressure test etc. Subsidence conditions should be considered where appropriate. Where necessary, heating shall be provided to prevent ground freezing and frost heave.

3. ACCESS TO THE INSTALLATION

3.1 Personnel

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

3.2 Access to Installation Controls

Filling connections and equipment controls shall be located in such a way that easy access is provided.

Filling connections and associated equipment controls should be located close to each other. The tank and tanker controls shall be visible and easily accessible from the operator's position.

3.3 Notices

3.3.1 General Precautions

Notices shall be clearly displayed so as to be visible at all times on or near the tank, particularly at access points; the following should be considered:

- LIQUID OXYGEN
- NO SMOKING
- NO HOT WORK
- NO NAKED LIGHTS
- NO STORAGE OF OIL, GREASE OR COMBUSTIBLE MATERIALS
- AUTHORISED PERSONS ONLY

Symbols should be used instead of written notices wherever possible, e.g.:

No unauthorised access

Oxidising Substance

No naked flames

No Smoking

These signs shall comply with the Health & Safety (Safety Signs and Signals) Regulations 1996 (24) and with BS 5378 "Safety Signs and Colours" Parts 1, 2 & 3 (25).

3.3.2 Identification of Contents

The storage tank should be clearly labelled 'LIQUID OXYGEN'.

The connection fittings of multi-storage installations or long fill lines shall be clearly marked with the contents or the chemical symbol in order to avoid confusion. (See also 1.4.7).

3.3.3 Legibility of Notices

All displayed warning signs and labels shall be legible, visible and up-to-date at all times.

3.3.4 Operating and Emergency Instructions

Operating and emergency instructions shall be available and understood before commissioning the installation. (See also 6.4).

These instructions shall be kept legible and up-to-date.

4. TESTING AND COMMISSIONING

4.1 Testing of Installation

Prior to testing and commissioning, measures shall be taken to ensure that the subject systems have been designed and constructed in accordance with recognised pressure vessel/piping system codes and that all statutory requirements have been met.

These measures will normally take the form of review of drawings of pressure vessels and piping systems, manufacturing certificates and construction specifications.

Checks shall also be made to ensure that the cleanliness requirements of paragraph 1.2.3 have been met.

In addition, the following tests shall be carried out in accordance with approved procedures.

4.1.1 Pressure Test

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

In order to verify the integrity of the installation, a pressure test shall be carried out on **site-erected** vessels/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. Care should be taken to prevent a vacuum condition arising in the inner vessel during draining.

Where a pneumatic test is specified, the appropriate safety precautions shall be taken and 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.

Pneumatic pressure testing is potentially hazardous and should be carried out in accordance with HSE GS4 Safety in Pressure Testing (26).

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

A leak and function test shall be carried out in accordance with GS4 and at a pressure in accordance with the applicable code or regulation.

Pressure tests/leak tests shall be witnessed by a Competent Person, and a test certificate signed and retained in the tank dossier.

4.1.2 Pressure Relief Devices

Relief valves shall have been subjected to a successful functional test and certified as such. (See Appendix 7).

A check shall be made to ensure that any gagging pins, transit locking devices/plugs have been removed from pressure relief devices of the inner vessel, outer jacket and piping systems and that the devices are undamaged, and seals are intact.

The relief device set pressure (stamped on or attached to each device) shall be checked to see that it is in accordance with the maximum permissible operating pressure of the system.

4.1.3 Under-pressure Prevention Devices

A check shall be made to ensure that any transit locking devices have been removed and that the under-pressure prevention device is undamaged.

4.1.4 Supports

A check shall be made to ensure all relief valve or bursting disc vent lines are positioned such that any discharge cannot impact on personnel or equipment and that the valves and vents are properly supported to take into account reaction forces.

4.2 Adjustment of Process control devices

Process controls shall be adjusted to the required operating conditions of the system and then be subjected to a functional test.

4.3 Posting of Notices

Notices (see 3.3) shall be posted before putting the installation into service.

4.4 Commissioning

Commissioning shall only be carried out by authorised personnel and in accordance with a written procedure. (See Section 4.1 for pre-commissioning measures).

5. OPERATION, INSPECTION AND MAINTENANCE

5.1 Operation of the Installation

Only authorised persons shall be allowed to operate the installation. Operating instructions shall be supplied to operating personnel and shall reflect current operational practice.

The instructions shall define the safe operating limits of the system and any special procedures, which may be required to operate the system in an emergency situation. In general such instructions should be written and presented in a clear concise format.

If, during the operation of the installation, an excursion occurs outside the design or safe operating limits of the system (e.g. overpressure, rapid temperature change, mechanical damage, etc.), it shall be recorded in the tank dossier and a programme of inspection shall be drawn up by a Competent Person and implemented. (See paragraph 5.2.2).

5.2 Periodic Inspection and Maintenance

5.2.1 General

The adoption of the Pressure Systems Safety Regulations 2000 (27) (which will be referred to as 'the Regulations' in this Code of Practice) has introduced specific requirements covering design, manufacture, installation, operation, maintenance and examination of pressure systems.

BCGA Code of Practice CP24 (28) details the requirements of the Regulations as applied to cryogenic liquid storage systems at production sites.

For the purpose of clarification in this document, the terms 'inspection', 'checks' and 'regular test' are activities associated with the normal operation of the installation.

The term 'Examination' means examination in accordance with the Written Scheme as detailed in the Regulations and CP24.

The site should be inspected regularly to ensure that it is maintained in a proper condition and that safety distances are respected.

A comprehensive installation dossier shall be held on site. This dossier shall include:

- Process and instrumentation diagram(s)
- Tank dossier
- Operating instructions
- Written Scheme of Examination
- Maintenance programme.

5.2.2 Tank Installation

An annual external visual inspection should be carried out by a Competent Person in accordance with a Written Scheme of Examination to confirm the satisfactory condition of the outer containment jacket and associated exposed pipework, valves, controls and auxiliary equipment. Periodic examination of the tank support structure should be carried out where appropriate. When a tank is taken out of service for modification or maintenance the accessible areas of the tank including the outer jacket, vessel, pipework, valves, controls and auxiliary equipment should be examined by a Competent Person prior to re-commissioning.

Periodic monitoring should be carried out of either the insulation space vacuum or the composition of the purge gas in the insulation space, to identify the existence of any inner tank leaks and to confirm the purge is still effective.

The supply of purge gas to large non-vacuum insulated tanks should be checked periodically to ensure an effective purge is being maintained.

When soil conditions are uncertain, a regular monitoring of the stability of the tank foundations should be carried out.

5.2.3 Inner Vessel

After manufacture and prior to commissioning, the inner vessel shall be validated as fit for service for a defined period by a Competent Person (See 1.4.2). Thereafter the vessel should be revalidated periodically while in service for a further defined period.

Revalidation should be based on a documentation assessment and an assessment of the vessel condition.

The documentation assessment should include consideration of the original design code and amendments which may have occurred in the intervening period, the history of the vessel in service, experience with similar vessels elsewhere and any change in operating conditions.

The assessment of the vessel condition should be based on a Written Scheme agreed by the operator and a Competent Person. This will be influenced by the documentation assessment, the established periods between revalidation, foreseeable modes of failure, particular features of the vessel design and contents, the possible detrimental effects of warming the inner vessel and, contamination.

There are sound technical and operational reasons for not warming up a vessel to ambient temperature.

The specific revalidation requirements for the vessel and the required frequency shall be defined and confirmed in writing for inclusion in the tank dossier by the Competent Person, taking into account the documentation assessment and the assessment of the vessel condition. This shall equally apply to vessels already in service prior to the issue of this Code of Practice.

Guidance on assessment is given in BCGA Code of Practice CP25 (29).

5.2.4 Pressure Relief Devices

Requirements for relief device inspection and testing are given in Appendix 7, which is derived from IGC document 24/83/E (30).

Regular visual inspection of the devices shall be carried out during normal operation.

Bursting disc elements may deteriorate due to aggressive environments resulting in their relief pressure rating being reduced. It may therefore be necessary to replace disc elements in such environments on a planned basis.

5.2.5 Emergency Isolation Valve(s)

Emergency isolation valves should be periodically tested in accordance with a prescribed procedure to check correct functional operation.

5.2.6 Ancillary Equipment

Ancillary equipment (other than previously detailed) shall be maintained so as to be safe.

5.3 De-commissioning

When a tank is to be 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.

6. TRAINING AND PROTECTION OF PERSONNEL

6.1 Training of Personnel

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

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

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

- Potential hazards of oxygen
- Site safety regulations
- Emergency procedures
- Use of fire fighting equipment
- Use of protective clothing/apparatus including breathing sets where applicable
- First aid treatment for cryogenic burns.

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

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

The training programme should make provision for refresher courses on a periodic basis and for changes of site personnel.

6.2 Permit to Work

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.

6.3 Entry into Vessels

Before entering any tank, vessel or interspace during maintenance or decommissioning, it is essential that the equipment is safe for the work to be carried out. The following precautions, which are not necessarily all those required, shall be observed and included as conditions for the issue of the Permit to Work:

- Complete emptying and purging of the vessel contents
- Confirmation that the inner vessel is approximately at ambient temperature before entry is permitted
- Analysis of the atmosphere in the vessel and/or interspace at several selected points with a suitable gas detector (probes may be necessary) to ensure that the oxygen content is in the range 20 to 21%. It may be necessary to measure this regularly or continuously and to install forced ventilation while work is in progress
- Complete isolation of the interspace purge lines and of process lines from other equipment, which may still be in service, by physical disconnection of a section of pipeline. Blanking discs may be used but they must be of appropriate material and thickness for the gas pressure in the pipe
- Presence of standby person(s) outside the tank adjacent to the access manhole to monitor the work in progress and provide assistance in the event of an emergency
- Use of appropriate safety equipment such as harnesses, protective clothing, fire extinguishers, etc.
- Availability of rescue equipment (harnesses, self contained breathing apparatus, winches, radio links, etc.).

The Confined Spaces Regulations 1997 (19) shall be consulted for more detailed information on this subject.

6.4 Emergency Procedures

Emergency procedures shall be prepared by the site operator to include action to be taken in the event of spillage of liquid oxygen. (See paragraph 3.3.4). For general guidance on preparing an emergency plan see HSE booklet HS(G)191 (31). Local emergency services shall be party to the preparation of the emergency procedures. Works employees likely to be affected shall know the actions required to minimise the adverse effects of a spillage. Consideration shall be given to the carrying out of practical exercises.

The following are guidelines, which should be used for formulating emergency procedures:

- Raise the alarm
- Summon help and emergency services
- Isolate the source of oxygen, if appropriate and where safely possible
- Evacuate all persons from the danger area and seal it off
- Alert the public to possible dangers from vapour clouds in the immediate vicinity and evacuate when necessary.

After the liquid spillage has been isolated, oxygen enrichment checks should be carried out in any enclosed areas where the vapour cloud may have entered. This includes basements, pits and confined spaces.

7. REFERENCES

(1)	IGC Document No 21/85/E*	Bulk liquid oxygen storage at production sites.
(2)	HMFI/ Air Products Ltd/ BOC Ltd	A Code of Practice for the Bulk Storage of Liquid Oxygen at Production Sites 1974. (Superseded by this document).
(3)	IGC Document 11/82/E*	Code of practice for the design and operation of centrifugal liquid oxygen pumps.
(4)	BCGA Code CP 19	Bulk liquid oxygen storage at users' premises.
(5)	IGC Document No 33/86/E *	Cleaning of equipment for oxygen service - Guidelines.
(6)	BS 5429	Code of practice for safe operation of small-scale storage facilities for cryogenic liquids.
(7)	ISBN 0 8543 26057	British Cryoengineering Society - Cryogenics Safety Manual.
(8)	SI 2003 : 1976	Fire Certificates (Special Premises) Regulations 1976.
(9)	SI 1357 : 1982	The Notification of Installations Handling Hazardous Substances Regulations 1982.
(10)	SI 743 : 1999	Control of Major Accident Hazards Regulations 1999.
(11)	BCGA Technical Report TR3	Replacement substances for the cleaning of oxygen system components.
(12)	PD 5500	Specification for Unfired Fusion Welded Pressure Vessels.
(13)	BS 7777:Part 4	Design and construction of single containment tanks for the storage of liquid oxygen, liquid nitrogen or liquid argon.
(14)	ANSI/ASME B31.3	Chemical plant and petroleum refinery piping.
(15)	BS 6399 Part 2	Code of practice for wind.
(16)	BS 6759 Part 3	Specification for Safety Valves for Process Fluids.

(17)	BS 2915	Specification for Bursting Discs and Bursting Disc Devices.
(18)	IGC Document 04/93/E *	Fire Hazards of Oxygen and Oxygen Enriched Atmospheres.
(19)	SI 1713 : 1997	Confined Spaces Regulations 1997.
(20)	BS EN 60079	Electrical apparatus for explosive gas atmospheres. Part 14.
(21)	BS 6651	Code of Practice for Protection of Structures Against Lightning.
(22)	BCGA Technical Report (LOX) TR1	A Method for Estimating the Off-site Risks from Bulk Storage of Liquefied Oxygen R1 (LOX).
(23)	SI 2095 : 1996	The Carriage of Dangerous Goods by Road Regulations 1996.
(24)	SI 341 : 1996	Health & Safety (Safety Signs and Signals) Regulations 1996.
(25)	BS 5378	Safety Signs and Colours Parts 1, 2 and 3.
(26)	HSE GN GS4	Safety in Pressure Testing 1976.
(27)	SI 128 : 2000	The Pressure Systems Safety Regulations 2000.
(28)	BCGA Code CP 24	Application of the Pressure Systems Safety Regulations 2000 to Operational Process Plant.
(29)	BCGA Code CP 25	Revalidation of Bulk Liquid Oxygen, Nitrogen, Argon and Hydrogen Cryogenic Storage Tanks.
(30)	IGC Document 24/83/E*	Cryogenic Pressure Vessels - Pressure Protection Devices.
(31)	HS(G)191	Emergency Planning for Accidents: COMAH Regs. 1999.
(32)	HS (G) 34	Storage of LPG at fixed installations.
(33)	LPGA COP 1	Code of Practice – Installation and Maintenance of bulk LPG at consumers' premises.
(34)	BS EN 12300	Cryogenic vessels: cleanliness for cryogenic service

(35)	BCGA Technical Report TR2	The Probability of Fatality in Oxygen Enriched Atmospheres due to Spillage of Liquid Oxygen.
(36)	IGC Document 59/98*	The prevention of excessive pressure in cryogenic tanks during filling.
(37)	BS 6869	Code of Practice for procedures for ensuring the cleanliness of industrial process measurement and control equipment in oxygen service.
(38)	SI 2001 : 1999	The Pressure Equipment Regulations 1999.
(39)	BS EN 60529:1992	Degrees of protection provided by enclosures.

Legislation generally applicable to storage of LOX at Production Sites:

- Housing and Planning Act 1986 Part iv – Hazardous Substances.
- The Health and Safety at Work etc Act 1974.
- The Factories Act 1961.
- The Offices Shops and Railway Premises Act 1963.

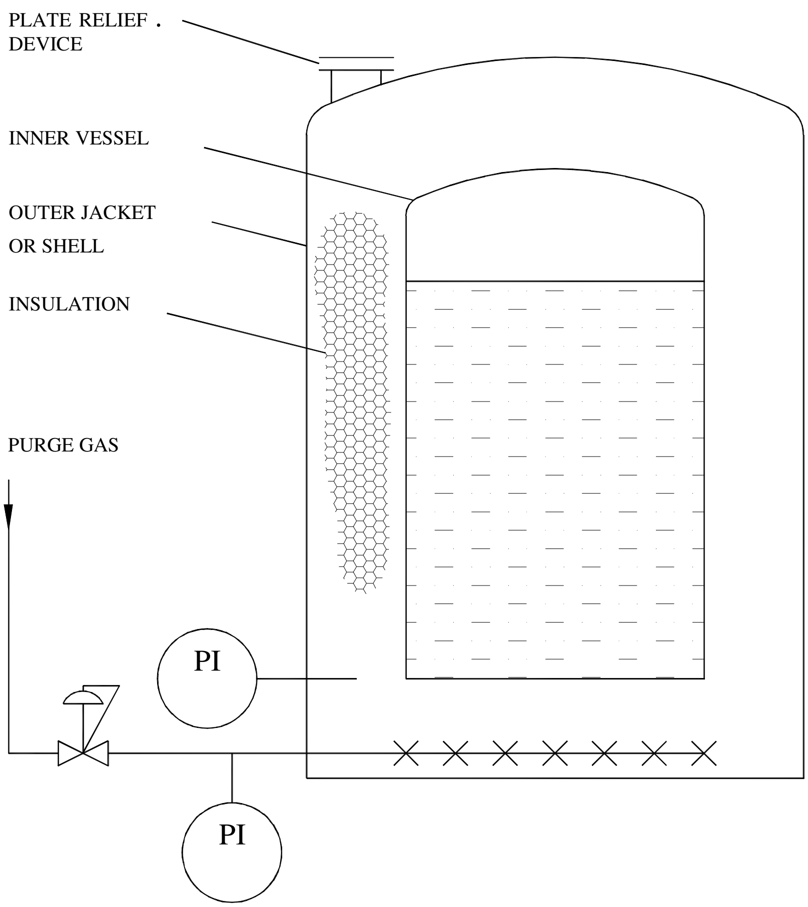
* A European Industrial Gases Association (EIGA) publication prior to 2000 available from:

Publications du Soudage et de ses Applications (PSA)
B.P. 50362
F-95942 Roissy CDG Cedex, France
Tel 00 33 (1) 49 90 36 00 Fax 00 33 (1) 49 90 36 50

Publications, including revisions, from 2000 onwards are obtainable from EIGA
Website: www.eiga.org
e-mail: info@eiga.org

TYPICAL BULK STORAGE TANK SYSTEMS

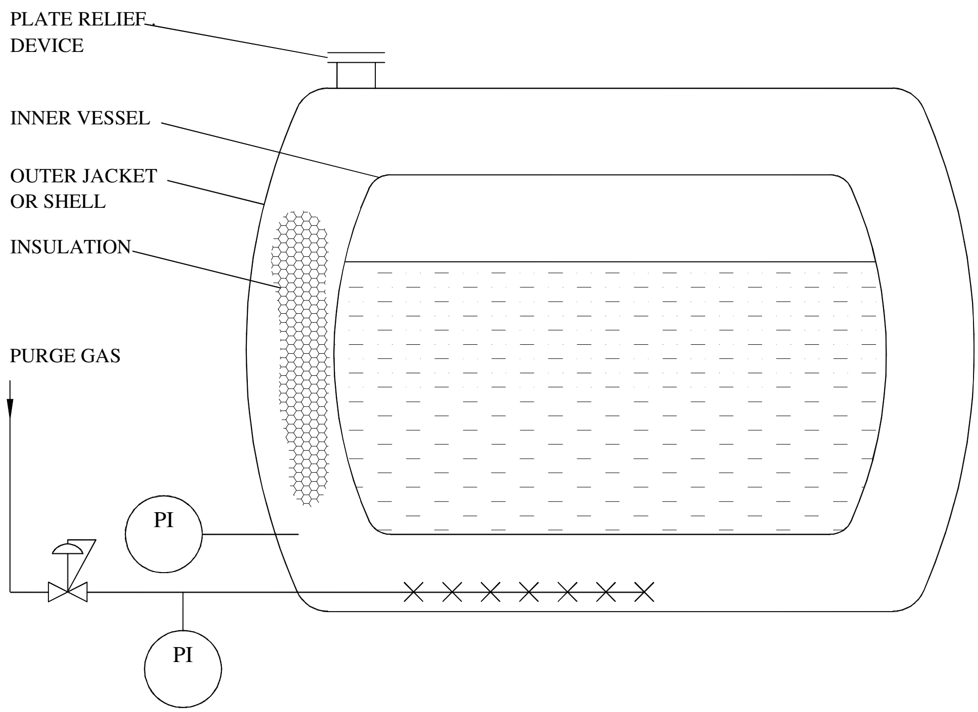
1 FLAT BOTTOM TANKS



Large, site-fabricated inner vessel resting on insulant blocks and surrounded by site-fabricated outer jacket. The inter-space is filled with granular insulant and purged with inert gas.

TYPICAL BULK STORAGE TANK SYSTEMS

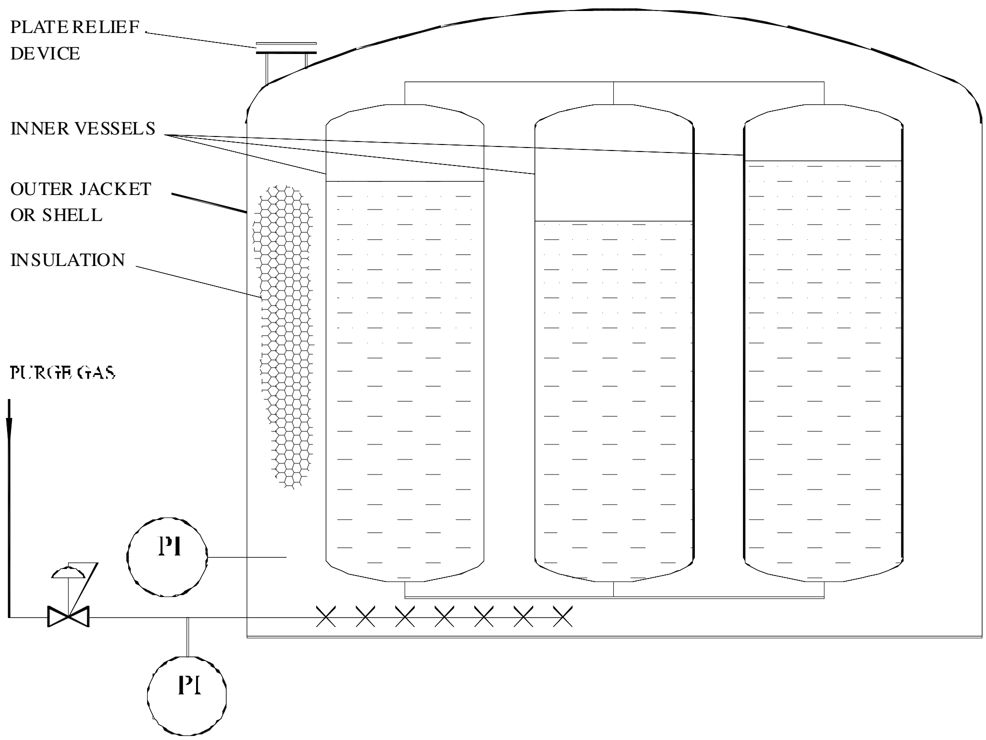
2 CYLINDRICAL AND SPHERICAL BULK



Smaller tanks may be shop-fabricated, larger tanks are site-built. The interspace is filled with granular insulant and purged with inert gas. This type of storage tank is operated at higher pressure than the flat-bottom type.

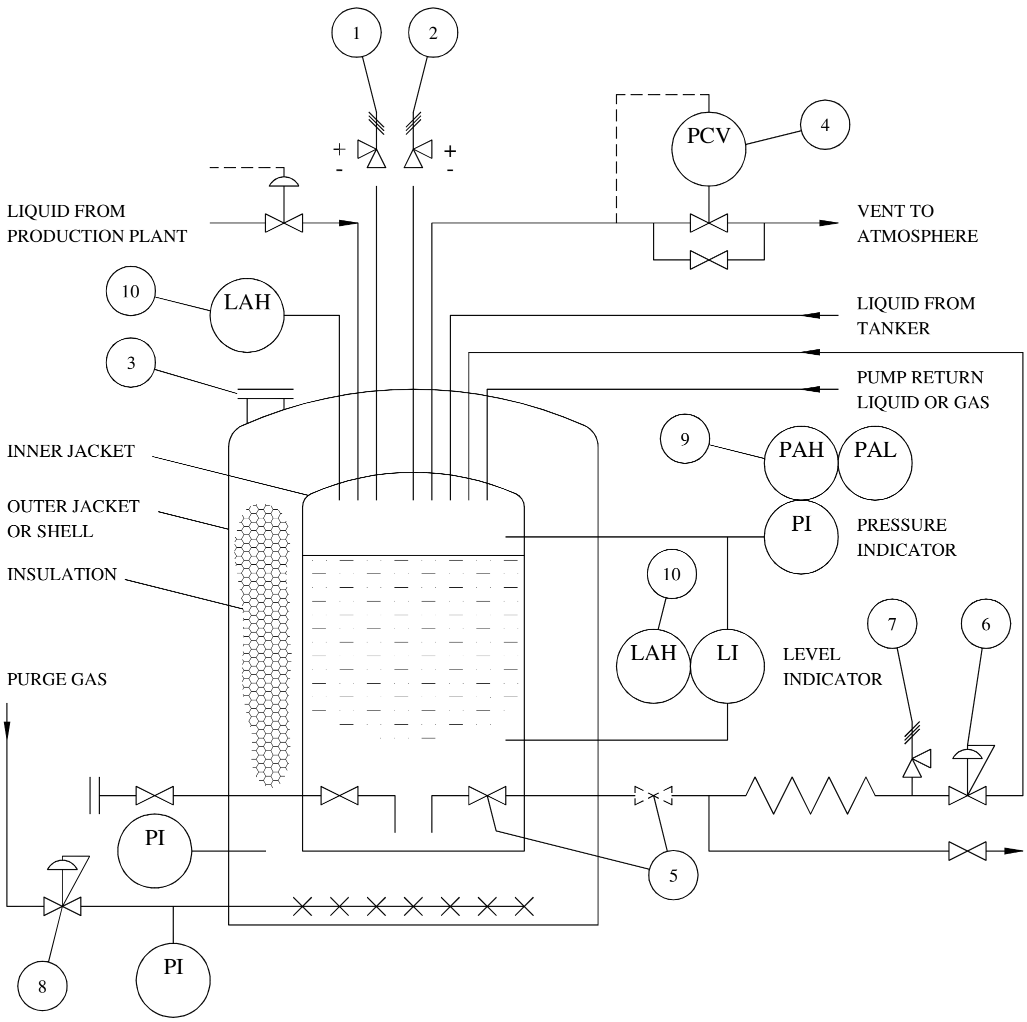
TYPICAL BULK STORAGE TANK SYSTEMS

3 CLUSTER OR AGGREGATE TANKS



A number of shop-built inner vessels contained within a single site-fabricated outer jacket. The interspace is filled with granular insulant and purged with inert gas. Piping arrangements may permit more than one product to be stored within a single outer jacket. The piping flow sheet is similar to the flow sheet for the flat-bottom type of tank

SCHEMATIC (FLAT BOTTOM TANKS)



Large site-fabricated inner vessel resting on insulant blocks, surrounded by site-fabricated outer jacket. The inter-space is filled with granular insulant and purged with inert gas.

LEGEND

1	Over/under-pressure protection device.
2	Over/under-pressure protection device.
3	Plate-relief device.
4	Pressure control valve.
5	Emergency shut-off valve (internal or external).
6	Pressure raising regulator.
7	Thermal relief valve.
8	Purge gas regulator.
9	Pressure alarm high and pressure alarm low.
10	Level alarm high.

HAZARDS FROM OXYGEN ENRICHMENT

Fire Hazards from Oxygen Enrichment

Oxygen reacts with most elements. The initiation, speed, vigour and extent of these reactions depend in particular upon:

- The concentration, temperature and pressure of the reactants
- Ignition energy and mode of ignition.

Reaction Mechanism

The mechanism of these reactions is complicated and depends, among other things, upon the nature of the substances concerned, their physical state, geometric configuration, concentration and manner of ignition. This, too, influences the speed of reaction, which can vary from slow combustion to an explosion.

Combustibility of Materials

Oxygen enrichment of the atmosphere, even by a few percent, considerably increases the risk of fire. Materials, which do not burn in air, including fireproofing materials, may burn vigorously or even spontaneously in enriched air.

Combustion Characteristics

Oxygen enrichment alters considerably the characteristics of combustion.

Materials, which would normally be regarded as harmless, ignite more easily and sparks can cause fire. The resulting flames are much hotter and are propagated at much greater speed.

Hydrocarbon Oils and Grease

Oil and grease are particularly hazardous in the presence of oxygen as they ignite spontaneously and burn with explosive violence. They should NEVER be used to lubricate oxygen or enriched air equipment. Special lubricants, with which oxygen can be used under certain conditions, are available.

Smoking

Burning accidents, which occur, are normally triggered by the lighting of a cigarette. Therefore it is impossible to over-emphasise the danger of smoking in oxygen-enriched atmospheres or where oxygen enrichment can occur. In such areas smoking shall be forbidden.

"BURNS" DUE TO VERY COLD LIQUEFIED GASES

The temperature of liquefied gases varies. The boiling points at 1.013 bar, i.e. the temperatures at which the liquefied gas vaporises, are as follows:

Helium	-269°C
Nitrogen	-196°C
Argon	-186°C
Oxygen	-183°C
Ethylene	-104°C
Propane	- 42°C

General Effect on Tissue

The effect of extreme cold on tissue is to destroy it, a similar end result to that of heat exposure, and the amount of cold and the duration of contact is therefore 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 become more apparent as thawing occurs. Those who have had mild frostbite of fingers or toes will have some idea of the pain on re-warming.

Prevention of contact with very cold liquids is vital and those who work in this field must be aware of the hazard.

Skin Effects

Liquid, vapour or low temperature gas can produce effects on the skin, which will vary in severity with temperature and the length of exposure. Naked or insufficiently protected parts of the body coming into contact with un-insulated pipes or vessels may stick fast by virtue of the freezing of moisture and flesh may be torn in removal. The wearing of wet clothing should be avoided.

Continued exposure of naked flesh to cold atmospheres can result in frostbite. There usually is sufficient warning by local pain whilst the freezing action is taking place. Re-warming at 42-44°C (108-111°F), a temperature equivalent to lukewarm water, is generally sufficient safeguard against injury.

Effect of Cold on Lungs

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.

FIRST AID TREATMENT OF COLD CONTACT BURNS

Flush the affected areas of skin with copious quantities of tepid water, but do not apply any form of direct heat, e.g. hot water, room heaters, etc. Move casualty to a warm place (about 22°C; 295K). If medical attention is not immediately available, arrange for the casualty to be transported to hospital without delay.

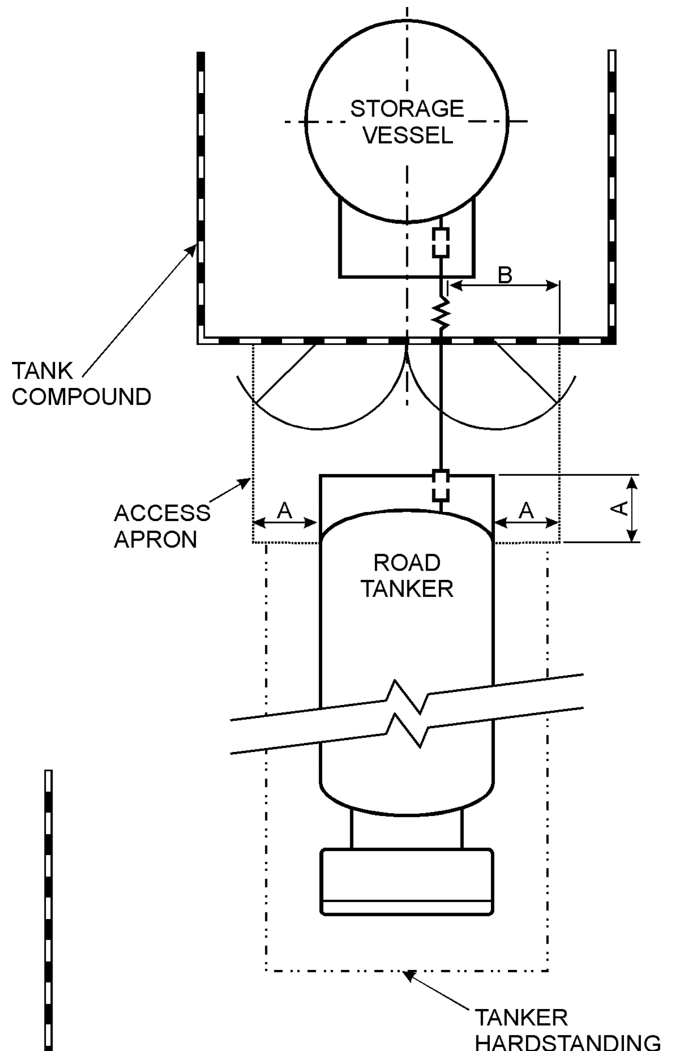
While waiting for transport:

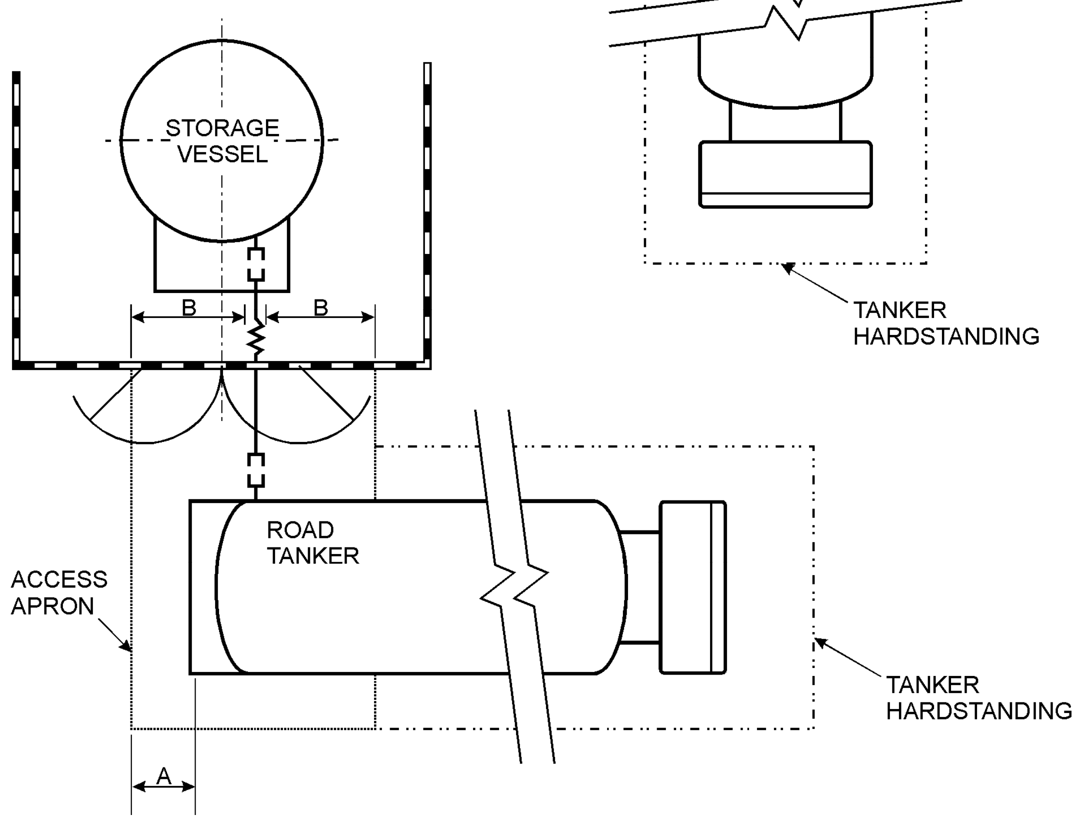
- Loosen any restrictive clothing.
- Continue to flush the affected areas of skin with copious quantities of tepid water.
- Protect frozen parts with bulky, dry, sterile dressings. Do not apply too tightly so as to cause restriction of blood circulation.
- Keep the patient warm and at rest.
- Ensure ambulance crew or hospital is advised of details of accident and first aid treatment already administered.
- Smoking and alcoholic beverages reduce the blood supply to the affected part and should be avoided.

The above text has been reproduced with the permission of the British Cryoengineering Society from its "Cryogenics Safety Manual", Reference No. ISBN 0-8543-26057 (7).

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.





LEVELS OF LOX STORAGE THAT TRIGGER LEGISLATIVE REQUIREMENTS

Trigger Quantity (te)

135	Fire Certificate (Special Premises) Regulations 1976 (SI 2003) (8).
500	The Notification of Installations Handling Hazardous Substances Regulations (NIHHS) 1982 (SI 1357) (9).
Any Quantity *	Control of Major Accident Hazards Regulations (COMAH) 1999 (SI 1743) (10).
2000	Reg 7 - 12 (COMAH) Control of Major Accident Hazards Regulations 1999 (SI 1743) (10) .

* All LOX production sites are subject to Regulations 4 and 5 of the Control of Major Accident Hazards Regulations (COMAH) 1999 (SI 1743) (10).

Basis for Estimating Quantities

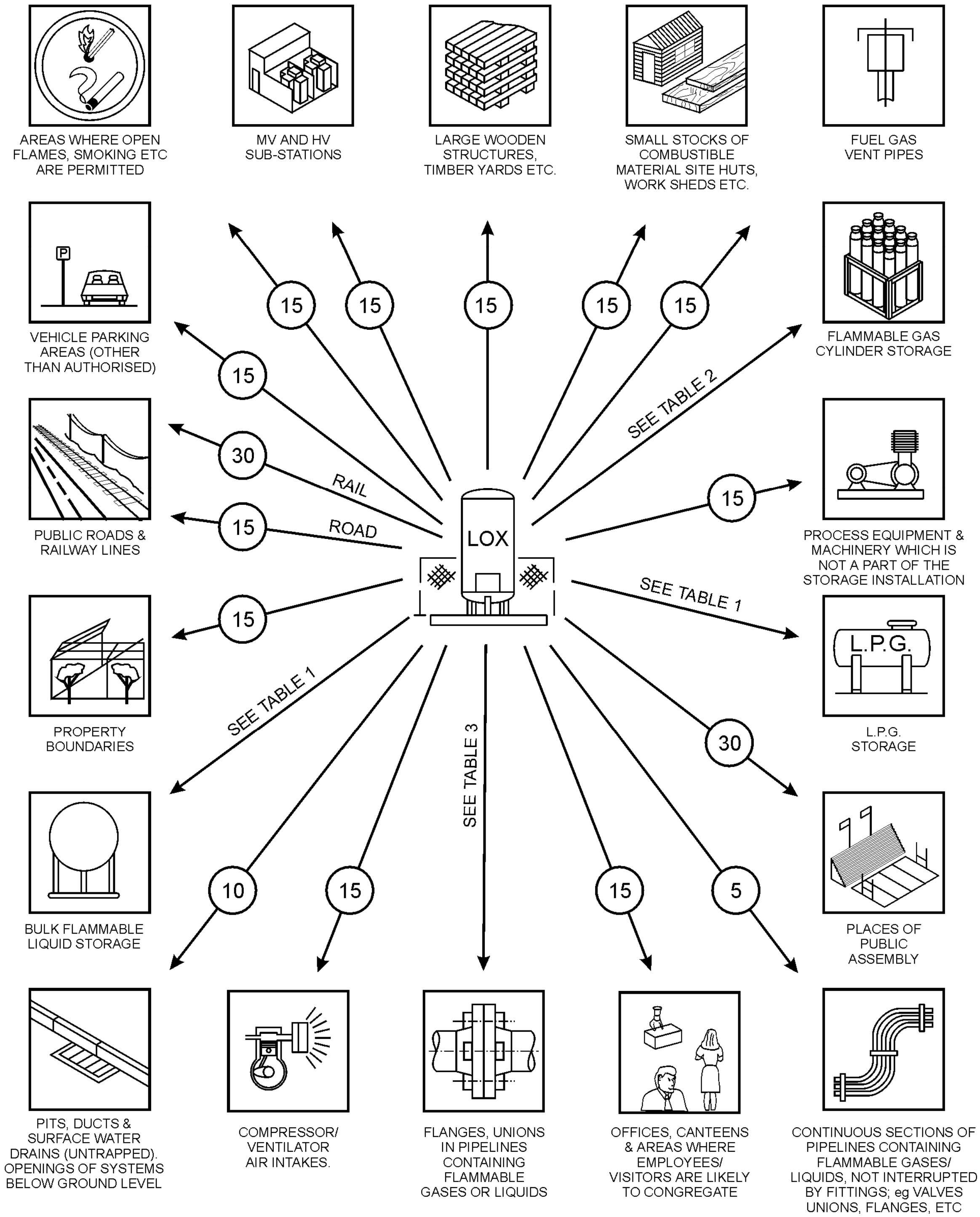
For the purposes of the above regulations, the quantity of liquid oxygen on site should be estimated on the basis of the maximum storage that is possible taking into account the amount of liquid oxygen in storage tanks, process vessels and pipework. No account shall be taken of liquid oxygen in vessels used for transport unless it can be considered as storage, i.e. a full liquid oxygen tanker parked on site overnight is considered to be 'storage'.

Notification

The notification procedure and the information required is clearly described in the relevant regulations.

FIG 1. SAFETY DISTANCES IN METRES

Distance between oxygen storage tanks above 200 tonnes capacity and typical hazards.



NOTE (1) The safety distances are measured from the exposure to whichever is the lesser of:
a) Any point on the storage system where, in normal operation, leakage or spillage can occur.
b) The tank outer jacket.
c) The vessel nozzles.

NOTE (2) For buildings the distances are measured to the nearest opening: ie door, window, vent etc.

NOTE (3) For tanks of less than 200 tonnes oxygen capacity refer to BCGA Code CP19.

TABLE 1: SEPARATION DISTANCES: LIQUEFIED FLAMMABLE GASES, FLAMMABLE LIQUIDS AND OXYGEN STORAGE

a) LPG Storage

Size of Storage			Separation Distance
Liquid Oxygen Vessel	LPG Vessels		
tonnes	Weight Capacity tonnes	Equivalent Liquid Capacity m^3 at 15°C	Metres
Above 200	0 - 2	0 - 4	30.0
	2 - 220	4 - 430	45.0
	220 and above	430 and above	Individual Assessment Required
	LPG cylinders and other liquefied flammable gas* cylinders above 50 kg total capacity.		7.5

See also HS(G) 34 (32), and LPGA COP 1 (33).

(b) Other Bulk Flammable Liquids and Liquefied Flammable Gases

The separation distances listed above for LPG should apply to the same stored volumes (m^3) of other bulk liquefied flammable gases and may be used for the same stored volumes (m^3) of bulk flammable liquids #. These distances may be reduced depending on the nature of the flammable liquid and any protective measures and in these cases an individual assessment of the proposed location shall be carried out.

* Common examples include: ammonia, hydrogen sulphide and ethylene oxide.

\# Common examples include: acetone, methanol, diesel and petrol.

TABLE 2: SEPARATION DISTANCES: COMPRESSED FLAMMABLE GASES AND OXYGEN STORAGE

Compressed Flammable Gas Cylinders (Gas volume measured at 1013 mbar and 15°C) m^3	Liquid Oxygen Storage above 200 tonnes Separation Distance Metres
Up to 200 Above 200	15.0 30.0
Flammable Gases stored at atmospheric pressure and 15°C	
Up to 1500 Above 1500	15.0 30.0

Notes:

1) For liquefied flammable gas cylinders, see Table 1.

2) These distances may be reduced depending on the nature of the flammable gas and any protective measures and in this case an individual assessment of the proposed location shall be carried out.

TABLE 3: SAFETY DISTANCES FROM FLAMMABLE LIQUID OR GAS LINES WITH UNION FLANGES ETC TO LOX STORAGE

Flammable Liquid or Gas Line Size (Nominal)			Liquid Oxygen Storage above 200 Tonnes Separation Distance
	mm Bore	inches Bore	Metres
Up to	50	2	10.0
Above	50	2	15.0

Notes:

1. The above separation distances are intended to provide protection for the LOX storage tank against jet flame impingement from an ignited release from the flammable liquid/gas line.

2. The distances are based on LPG as the contents of the flammable liquid/gas line and are given as a ‘worst case’.

3. For flammable liquids or gases other than LPG in the line, the above distances should be used, unless it can be shown that smaller distances are adequate to avoid jet flame impingement.

4. If some means of protection from jet flame impingement (such as shielding of the joint by fire resistive material) can be provided between the union/flange on the flammable liquid/gas line and the LOX storage and this can be shown to provide an equal or greater degree of protection than the separation distances shown, the separation distances may be reduced.

RELIEF DEVICE INSPECTION, TESTING AND EXAMINATION

1. INTRODUCTION

The importance of pressure relieving devices (i.e. relief valves and bursting discs) to the bulk storage installation and their influence on safety cannot be overstressed. The requirements in paragraph 2 to 4 below shall be complied with for inner vessel relief devices. Paragraphs 5, 6 and 7 refer respectively to outer jacket and thermal relief devices and other relief valves associated with the installation.

2. INSPECTION OF INNER VESSEL RELIEF DEVICES PRIOR TO FIRST FITTING ONTO VESSEL

2.1 Relief valves shall be inspected at the manufacturer's works or at a suitable testing station to ensure compliance with the relevant design standard and specification. Inspection shall be carried out by a competent person independent of the manufacturer to ensure that:

2.1.1 The valve type, connections and materials are as specified.

2.1.2 The valve set pressure and reseat pressure are witnessed as being correct.

2.1.3 The valve has been properly cleaned for oxygen service.

2.1.4 Supporting certification covering the following is available and correct:

- Materials of construction.
- Strength testing.
- Functional testing to establish set pressure and reseat pressure.
- Limiting operating temperature.

2.1.5 The valve is properly lead sealed to prevent adjustment of the set pressure and blow-down.

2.1.6 Each valve has a stainless steel plate permanently attached detailing valve make and type, set pressure, limiting operating temperature, serial number, capacity and/or orifice size.

2.2 Bursting discs shall be verified by selecting representative samples from each production batch and burst testing to confirm that the rupture pressures are within the stipulated tolerance. The discs shall be inspected by a competent person independent of the manufacturer to ensure compliance with the relevant design standard and specification and that:

2.2.1 Each bursting disc is indelibly marked, tagged or labelled with the tag number, burst pressure and tolerance at coincident temperature, material and nominal size.

2.2.2 Each bursting disc holder is marked with the disc material, direction of flow, tag number and the nominal size and pressure of the disc.

2.2.3 All bursting disc assemblies have been properly cleaned for oxygen service.

2.2.4 Valid certification is available, recording the results of the witnessed burst tests together with the relevant batch numbers and tag numbers.

3. INSPECTION AFTER FITTING BUT PRIOR TO COMMISSIONING THE VESSEL

3.1 Visual inspection shall be conducted to ensure that:

3.1.1 Each relieving device is undamaged, in its correct location and properly fitted.

3.1.2 All gagging pins and transit locking devices/plugs, where fitted, are removed.

3.1.3 Relief valve or bursting disc vent lines are directed away from areas frequented by personnel and from vulnerable items of equipment.

3.1.4 All vent systems are adequately supported.

3.1.5 Each relief device is clearly identified.

3.1.6 Direction of flow is correct.

4. PERIODIC IN-SERVICE INSPECTION, TEST AND EXAMINATION

4.1 Pressure relief systems shall be visually inspected at regular intervals, as part of the normal plant operation. Blockages such as ice or foreign debris shall be removed and care taken to monitor for seat leakage, corrosion or other visual defects.

Blockages shall be investigated to determine the cause and action to be taken to prevent recurrence.

If necessary, the relief valve(s) shall be removed and sent to an approved person for testing, repair and retesting as appropriate. Alternatively the valve shall be removed and replaced by a valve, which has been inspected in accordance with the requirements detailed in paragraph 2.1 of this Appendix.

4.2 A Written Scheme for the periodic Examination of relief devices shall be implemented. Records shall be kept for all inspections and examinations, throughout the operating life of the pressure system.

It is recommended that reliability data be compiled by ensuring that whenever relief valves are removed, they are functionally tested to check set pressure and reseat pressure, prior to disassembly.

4.3 All inspections functional tests and periodic examinations shall be carried out by a Competent Person who is authorised by the tank owner to carry out such tests.

4.4 All maintenance and repairs of relief devices shall be completed by authorised personnel who have received adequate training relevant to the make and type of the relief device. Records shall be maintained to verify the competence of these personnel.

4.5 The recommended minimum frequencies for inspection, test and examination are listed in the following table:

	Within each 12 month period	***Within each 36 month period***
Relief Valves	B and (C* or D*)	A, B and D (Requirement of Written Scheme of Examination)
Pilot Operated Relief Valves	B and (C* or D*)	A, B and (C or D) (Requirement of Written Scheme of Examination)
Vacuum Relief Valves	B and (C* or D*)	A, B and (C or D)
Bursting Discs	B	A and B (Requirement of Written Scheme of Examination)

* Where local conditions could create problems such as corrosion.

A. THE DEVICE & DOCUMENTATION

This shall include checking of certificates, operational records, specifications, identification and markings.

B. THE INSTALLATION

This shall include visual inspection of the device, its piping and supports, for corrosion, leak tightness, identification, test date marking and mechanical integrity.

C. FUNCTIONAL TEST

The relief valve shall be checked to ensure that it lifts at its set pressure and reseats correctly. The test may be carried out in-situ or on a bench, using a calibrated pressure gauge.

D. REPLACEMENT OR OVERHAUL

The device shall be replaced by either a new or a fully certified and reconditioned unit or overhauled in situ.

Should for any reason a relief device be found, on inspection, to be defective or unsuitable for its purpose, then it shall be renewed or replaced without delay.

5. OUTER JACKET RELIEF DEVICES

Outer jacket relief devices shall be examined prior to fitting to ensure compliance with the design specification. They shall be periodically examined in accordance with the approved Written Scheme of Examination. The interval between examinations shall not exceed 36 months.

6. THERMAL RELIEF VALVES

Thermal relief valves installed to protect pipework shall be examined prior to fitting to ensure compliance with the design specification. They shall be periodically examined, in accordance with the approved Written Scheme of Examination. The interval between examinations shall not exceed 120 months.

7. RELIEF VALVES FOR OTHER DUTIES

Relief valves fitted to other parts of the storage installation shall be examined prior to fitting to ensure compliance with the design specification. They shall be periodically examined in accordance with the approved Written Scheme of Examination. The interval between examinations shall not exceed 72 months.

Note: The frequencies quoted in Sections 4, 5, 6 and 7 above are the minimum recommended in BCGA Code of Practice 24 (28).

HISTORY AND OBJECTIVES OF BCGA

The British Compressed Gases Association was established in August l971 as the successor to the British Acetylene Association, formed in l901. Its Members consist of producers, suppliers of gases equipment and container manufacturers and users operating in the compressed gas field.

The main objective of the Association is the advancement of technology and safe practice in the manufacture, handling and use of all gases and the design and manufacture of all containers, apparatus, appliances, plant, etc. BCGA also provides advice and makes representations, insofar as these relate to particular problems of the compressed gases industry, on behalf of its Members to all regulatory bodies, including the UK Government, concerning legislation both existing and proposed.

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.

Further details of the Association may be obtained from:

BRITISH COMPRESSED GASES ASSOCIATION
4a Mallard Way, Pride Park, Derby,
DE24 8GX
Tel 01332 225120
Website : www.bcga.co.uk

ISSN 0260-4809