# BCGA CODE OF PRACTICE 4

## Industrial Gas Cylinder Manifolds and Gas Distribution Pipework (excluding Acetylene)

**Revision 4: 2012**

British Compressed Gases Association

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## Industrial gas cylinder manifolds and gas distribution pipework (excluding acetylene)

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**BRITISH COMPRESSED GASES ASSOCIATION**

4a Mallard Way
Pride Park
Derby
DE24 8GX

Website: www.bcga.co.uk

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## PREFACE

The British Compressed Gases Association (BCGA) was established in l971, formed out of the British Acetylene Association, which existed since l901. 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 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.

This document has been prepared by BCGA Technical Sub-Committee 1. This document replaces BCGA CP 4, Revision 3: 2005. It was approved for publication at BCGA Technical Committee 143. This document was first published on 18/07/2012. For comments on this document contact the Association via the website www.bcga.co.uk.

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## TERMINOLOGY, FUNCTIONS AND DEFINITIONS

| | |
|---|---|
| **Shall** | Indicates a mandatory requirement for compliance with this Code of Practice. |
| **Should** | Indicates the preferred requirement but is not mandatory for compliance with this Code of Practice. |
| **May** | An option available to the user of this Code of Practice. |
| **Adiabatic compression** | Occurs when there is no heat transfer during the compression of a gas, either because of perfect insulation or because the change in pressure is so rapid that there is insufficient time for the heat, which is generated, to dissipate. This may happen if a valve in a system is opened too quickly, leading to rapid pressurisation of a system. This results in elevated temperatures and can lead to ignition in some cases, for example in oxygen systems. (See Appendix 1). |
| **Analysis point** | A sensing point for determining the gas composition within the pipework. |
| **Bursting disc** | A non re-closing pressure relief device actuated by differential pressure and designed to function by the rupture of the bursting disc. |
| **Contact type pressure gauge** | A pressure-sensing device with electrical contacts, adjustable for a required pressure signal. |
| **Cylinder bundle / Manifolded Cylinder Pallet (MCP)** | A number of cylinders permanently manifolded to a common outlet and contained in a rigid protective framework for ease of handling by forklift truck. |
| **Supply manifold** | A piping system connecting source pressure i.e. cylinders, cryogenic containers or cylinder packs to the distribution system.<br><br>Usually a manifold will consist of connecting pipes from the cylinders or bundles, or from cryogenic containers, feeding into a header with related valves and other devices. |
| **Cryogenic** | Appertaining to gases liquefied by deep refrigeration. |
| **Cryogenic container** | A vacuum insulated container containing a cryogenic fluid. |

| | |
|---|---|
| **Detonation** | A flame front which travels into the unreacted gas at a rate above sonic, usually several times the speed of sound. Detonation involves a sharp difference in pressure between the reacted and unreacted gas. The change from low pressure of the unreacted gas to the high pressure produced by the reacted gas takes place in a shock wave at the front of the flame. |
| **Filter** | An element capable of restraining particles which may interfere with the operation of downstream equipment. |
| **Flashback arrestor** | A device which arrests a flame front and which is suitable for the most severe type of flame which may occur, e.g. detonation. It shall be effective in stopping a flame coming from either one or both directions depending upon the application and design. Flashback may occur in systems using flammable gases and other than in acetylene systems, will normally require a mixture of the flammable gas and oxygen or the flammable gas and air to occur. |
| **Flowmeter** | A device for measuring gas flow by mass or volume. |
| **Orifice plate** | A plate with a sharp edged hole the dimensions of which have been calculated to create a pressure drop with the intention of limiting the flow through a system or providing sampling points for instrumentation. |
| **Outlet point** | An assembly including an isolation valve, together with other features identified in Table 2, fitted at the termination of the distribution pipework for connection of the user equipment. |
| **Pigtail / flexible hose assembly** | A flexible connection between two components in the system. It may be manufactured from coiled metal tube (pigtail) or flexible elastomeric material (hose). |

**Pressure:**

NOTE: Gauge pressures are used except where otherwise stated.

| | |
|---|---|
| Pressure unit | 1 bar = 100 kPa = 0.1 MPa = $10^5$ N/m$^2$ = 0.1 N/mm$^2$ = 14. 5 lbf/in$^2$ |
| Safe operating limits | For the purpose of this Code of Practice the definition of “safe operating limits” is restricted to the system design pressure and the maximum / minimum design temperatures. |
| Design pressure | The design pressure of the system is always less than or equal to the lowest design pressure of any component in the system. |

| | |
|---|---|
| Supply system pressure | Where the gas supply is from cylinders the minimum system design pressure shall be equal to the developed cylinder pressure at 60 $^{o}$C; this information may be obtained from the cylinder supplier.<br><br>Where the gas supply is from a cryogenic container the design pressure is normally equal to the set pressure of the highest protective device of the container. |
| Distribution system pressure | For the distribution system the design pressure is the lowest rated pressure of any component in the system. |
| Pressure drop | The loss of pressure through the system due to frictional forces and restrictions under flow conditions. |
| High Pressure (HP) | For the purposes of this code high pressure means greater than 50 barg and is typically the source pressure. |
| Low Pressure (LP) | For the purposes of this code low pressure means a pressure equal to or less than 50 barg and is typically the distribution pressure i.e. after the pressure regulation. |
| **Main pressure regulator** | A self-governing device for regulating a variable inlet pressure to the required outlet pressure. When used to regulate pressure from a high pressure permanent gas source, it is normal practice to use a multi-stage regulator. |
| **Auto change unit** | A device used to ensure continuity of supply between dual system gas supplies, normally situated in the manifold header and set to automatically change from the service bank to the reserve bank at a predetermined pressure. This device commonly has integral pressure regulators. However where pressure regulators are not an integral part of the unit a main pressure regulator is still required. |
| **Outlet point regulator** | A device for reducing distribution pipework pressure to that required by the user. |
| **Pressure gauge** | A device that indicates pressure. |
| **Purging:** | |
| Purging into service | The safe removal of air or any other gas that may be present in a system prior to the introduction of the service gas. |
| Purging out of service | Removal of the service gas from the system by replacement with an inert gas. |

**Pipework:**

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|---|---|
| Header | Pipework for collecting gas at cylinder pressure from one or more cylinders or gas containers. |
| Distribution | The pipework downstream of the cylinder regulator or manifold pressure regulator. |

**Valves:**

| | |
|---|---|
| Non-return valve | A self-actuating valve which prevents the passage of gas in the opposite direction to the normal flow. |
| Isolating valve | A valve which gives positive shut-off. |
| Pressure relief valve | A valve which automatically vents to prevent a dangerous build-up of pressure in a system when the pressure exceeds a predetermined value. The pressure relief valve automatically reseats when the conditions causing the over-pressure are corrected. |
| Pressure actuated shut-off valve | A self-actuating pressure-limiting device which shuts off the supply if the pressure down stream of the manifold regulator rises above the safe operating limit. |
| **Vaporiser** | A device for converting liquid to gas by heat transfer. |
| **Heater** | Sometimes required with certain gases to prevent temperature drop or ensure complete vaporisation of liquids. |
| **Safety shut-off device** | Device which automatically shuts off the gas supply when the set distribution pressure, flow or temperature is exceeded. |
| **Regulator mounting block** | A mounting block fitted to the header pipe or distribution pipe, threaded to accept the regulator. |
| **Alarm** | Device which provides visual or audible warning of change in conditions such as pressure, flow or temperature. |
| **Installation** | For the purpose of this Code of Practice the term installation is the combination of the supply system and distribution system. |

# BCGA CODE OF PRACTICE 4

## Industrial gas cylinder manifolds and gas distribution pipework (excluding acetylene)

### 1 INTRODUCTION

This is one of a series of related British Compressed Gases Association (BCGA) Codes of Practice (CP) under the following titles:

CP 4 Industrial gas cylinder manifolds and gas distribution pipework (excluding acetylene).

CP 5 The design and construction of manifolds using acetylene gas from 1.5 bar to a maximum working pressure of 17 bar (46).

CP 6 The safe distribution of acetylene in the pressure range 0 - 1. 5 bar (47).

CP 7 The safe use of oxy-fuel gas equipment (individual portable or mobile cylinder supply) (48).

CP 18 The safe storage, handling and use of special gases in the micro-electronics and other industries (49).

The BCGA is grateful for the active help and co-operation of the Health and Safety Executive (HSE) in the preparation of these Codes of Practice.

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.

Users of gas processes having gas supplies from manifolds or pipework are recommended to ensure that, after the issuing of these Codes, all new installations or modifications to existing installations comply with the relevant Codes for the products or services involved.

It is pointed out that the Codes represent the BCGA's view of minimum requirements for safe practice.

### 2 SCOPE

This Code of Practice gives the minimum safety standards for the design, construction, installation, operation, examination and maintenance of industrial gas supply manifolds and associated distribution pipework of up to 54 mm nominal bore. The manifolds are supplied by gas cylinders filled to a settled pressure of up to 300 bar gauge at 15 °C and maximum working pressures of up to 50 bar gauge. The maximum distribution pipework pressures are limited to 50 bar gauge for any of the following industrial grade gases:

Argon
Carbon Dioxide
Helium

Hydrogen
Liquefied Petroleum Gas
Methane
Nitrogen
Nitrous Oxide
Oxygen
Mixtures of the above gases

For higher purity gas systems special techniques are required and not addressed in this document.

This Code of Practice can also be used to design and construct single-cylinder permanently piped systems.

Requirements for acetylene manifolds are given in BCGA CP 5 (46).

Requirements for acetylene distribution are given in BCGA CP 6 (47).

Additional requirements for special gases are given in BCGA CP 18 (49).

Additional requirements for hydrogen systems larger than those covered by this code are given in BCGA CP 33 (51).

NOTES:

1) Storage of Gas Cylinders. The risks relating to the storage of gas cylinders are of a lower order than those of cylinders in use. Guidance on the storage of compressed gas cylinders is given in BCGA GN 2 – Guidance for the storage of gas cylinders in the workplace. (52).

2) This code of practice does not include medical gas pipeline systems. These are covered by Department of Health, Health Technical Memorandum HTM 02-01 (12).

3) This Code of Practice may also be used as guidance for the design and installation of gas distribution pipework systems supplied from, for example, cryogenic container installations, etc.

4) The Gas Safety (Installation and Use) Regulations 1998 (3) deal with the safe installation, maintenance and use of gas systems, including gas fittings, appliances and flues, mainly in domestic and commercial premises, e.g. offices, shops, public buildings and similar places. The Regulations generally apply to any ‘gas’ as defined in the Gas Act 1986 (1) (amended by the Gas Act 1995), apart from any gas comprising wholly or mainly of hydrogen when used in non-domestic premises. Thus most industrial installations are not covered by the Regulations. Where the Regulations do apply, such work shall only be carried out by persons registered as competent on the Gas Safe Register.

5) Gas Safe Register is the official gas registration body for the United Kingdom, Isle of Man and Guernsey, appointed by the relevant Health and Safety Authority for each geographical area.

## 3 SUPPLY SYSTEMS

The supply system is that part of an installation from the outlet of the gas cylinder, cylinder pack or cryogenic container storage to the main pressure regulating equipment as shown in Figure 1. The supply system shall be capable of withstanding maximum cylinder or cryogenic container pressure (refer to Terminology, Functions and Definitions, “Pressure”). Gas containers of different pressures or products shall not be connected to the same supply manifold e.g. a cryogenic container shall never be connected to the same supply manifold as a compressed gas cylinder.

The schematic arrangement for supply systems in Figure 1 shows all the components normally encountered for the range of gases covered by this Code of Practice. Only a few components will be required for most gases while others will be specific to individual gases. The schematic arrangement as shown is not intended for use as a specific installation. Table 1 identifies the various items and qualifies their status in respect of the various gases**.**

**Table 1 - Gas Supply / Component Relationship**

| **GAS SUPPLY** | **Cylinder valve(s)** | **Pigtail / flexible hose assembly** | **Non-return valve (4) or isolating valve (5)** | **Header** | **Bursting disc or pressure relief valve** | **Purge valve** | **Header valve** | **Heater** | **Vaporiser** | **Filter** | **Safety shut-off device** | **Regulator mounting block** | **High-pressure gauge** | **Main regulator or autochange with integral regulators** | **Low-pressure gauge** | **Temperature control valve** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ITEM** (defined in Figure 1) | 2 | 3 | 4 or 5 | 6 | 7 | 8 | 9 | 10A | 10B | 11 | 12 | 13 | 14 A | 14 | 14 B | 15 |
| **Oxygen** | E | E | E | E | N | O | E | N | N | E | O | O | R | E | R | O |
| **Nitrogen** | E | E | E | E | N | O | E | O | N | E | O | O | R | E | R | O |
| **Argon** | E | E | E | E | N | O | E | O | N | E | O | O | R | E | R | O |
| **Hydrogen** | E | E | E | E | N | R | E | N | N | E | O | O | R | E | R | O |
| **Carbon Dioxide** | E | E | E* | E | O | O | E | O | O | E | O | O | R | E | R | O |
| **Carbon Dioxide from a dip tube cylinder** | E | E | E* | E | E | O | E | O | E | E | N | O | O | O | O | O |
| **Helium** | E | E | E | E | N | O | E | O | N | E | O | O | R | E | R | O |
| **Methane** | E | E | E | E | N | R | E | N | N | E | O | O | R | E | R | O |
| **Nitrous Oxide** | E | E | E | E | N | O | E | N | N | E | O | O | R | E | R | O |
| **LPG (gas)** | E | E | E | E | N | O | E | N | N | E | O | O | O | E | O | O |
| **Mixed Gases** | See Appendix 9 – Mixed Gases | | | | | | | | | | | | | | | |

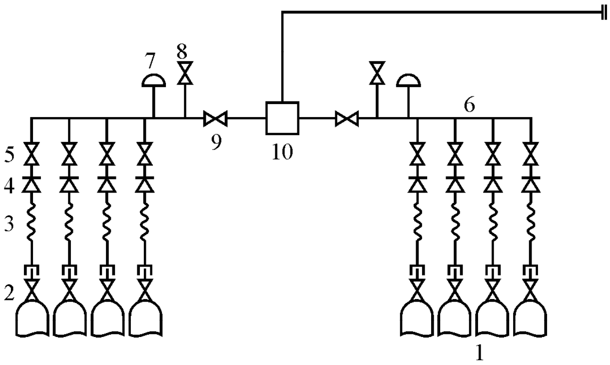
* The device used to prevent back-feed must comply with BCGA GN 10 (53).

E = Essential R = Recommended O = Optional N = Not Applicable

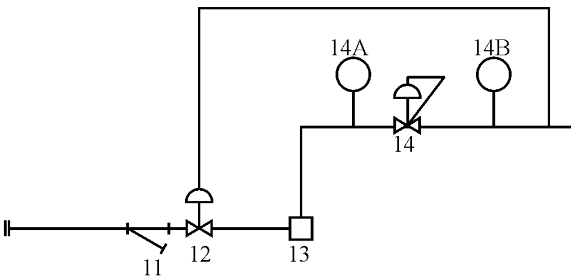
# SUPPLY SYSTEMS

FIGURE 1

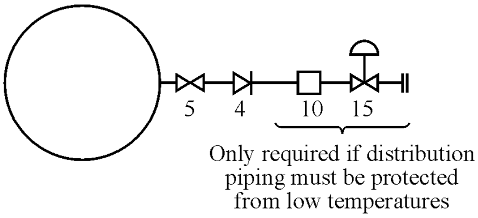
**CYLINDER MANIFOLD**



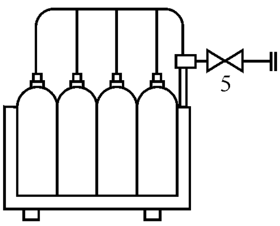

**PRESSURE CONTROL**




**CRYOGENIC CONTAINER**




**CYLINDER BUNDLE**




LEGEND

1. Gas Supply
2. Cylinder Valve(s)
3. Pigtail
4. Non-return Valve
5. Isolating Valve
6. Header
7. Bursting Disc/Pressure Relief Valve
8. Purge Valve
9. Header Isolating Valve

10. Heater/Vaporiser
11. Filter
12. Safety Shut-off Valve
13. Regulator Mounting Block
14A. HP Gauge
14. Regulator
14B. LP Gauge
15 Temperature Control Valve

## 4 DISTRIBUTION SYSTEMS

The distribution system is that part of an installation from the main pressure regulator equipment to the outlet point as shown in Figure 2. The distribution system pipework should be operated at a pressure below the maximum supply pressure (50 bar is the maximum distribution pressure covered by this Code of Practice). The distribution system shall be protected against over-pressurisation resulting from malfunction of the pressure regulator equipment or other abnormal circumstance.

The schematic arrangement of a distribution system in Figure 2 shows all the components which could normally be encountered for the range of gases covered by this Code of Practice. Only a few components will be required for most gases while others will be specific to individual gases. The schematic arrangement as shown is not intended for use as a specific installation.

Table 2 identifies the various items and qualifies their status in respect of the various gases.

**Table 2 - Gas Distribution / Component Relationship**

| **GAS DISTRIBUTION** | **Flexible hose** | **Flashback arrestor** | **Pressure relief valve bursting disc** | **Isolating valve** | **Pressure gauge** | **Analysis valve** | **Alarm** | **Isolating valve** | **Filter** | **Flow meter** | **Purge valve** | **Outlet isolation valve** | **Non-return valve** | **Flashback arrestor** | **Thermal cut-off valve** | **Outlet point pressure regulator** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ITEM** (defined in Figure 2) | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 27A * | 27B * | 27C * | 28 |
| **Oxygen** | O | O | E | R | O | O | O | R | O | O | O | E | R | R | R | O |
| **Nitrogen** | O | N | E | R | O | O | O | R | O | O | O | E | R | N | N | O |
| **Argon** | O | N | E | R | O | O | O | R | O | O | O | E | R | N | N | O |
| **Hydrogen** | O | O | E | R | O | O | O | R | O | O | O | E | R | R | R | O |
| **Carbon Dioxide (gas)** | O | N | E | R | O | O | O | R | O | O | O | E | R | N | N | O |
| **Helium** | O | N | E | R | O | O | O | R | O | O | O | E | R | N | N | O |
| **Methane** | O | O | E | R | O | O | O | R | O | O | O | E | R | R | R | O |
| **Nitrous Oxide** | O | O | E | R | O | O | O | R | O | O | O | E | R | R | R | O |
| **LPG (gas)** | O | O | E | R | O | O | O | R | O | O | O | E | R | R | R | O |
| **Mixed gases** | See Appendix 9 – Mixed Gases | | | | | | | | | | | | | | | |

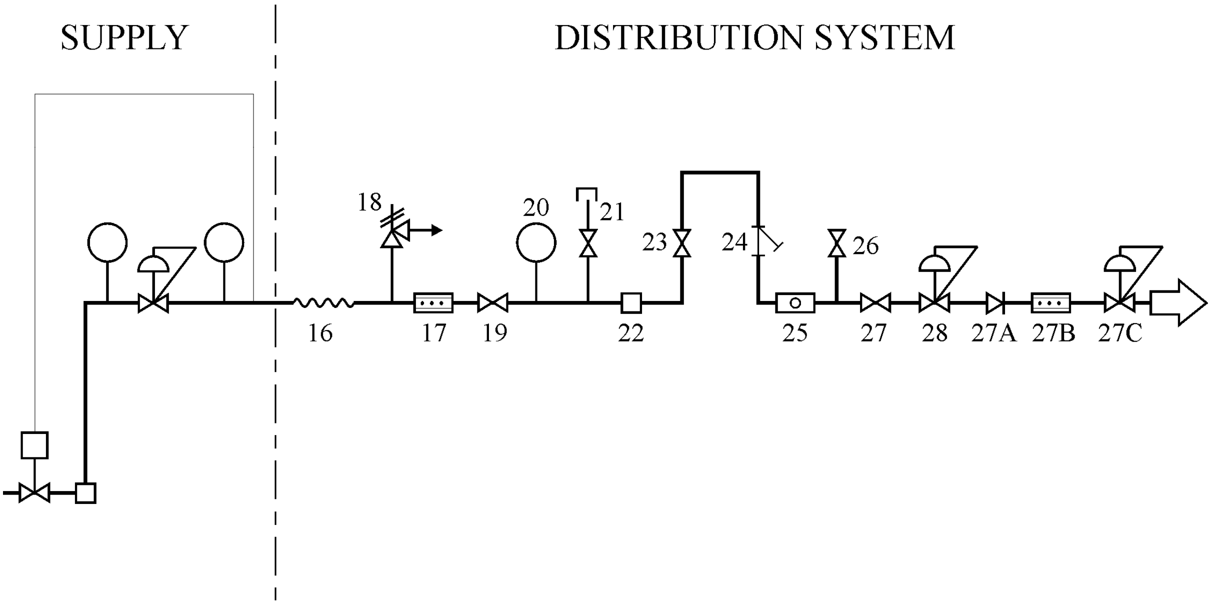
E = Essential R = Recommended O = Optional N = Not Applicable

*At least one of the items 27A or 27B or 27C shall be provided on oxygen and fuel gas distribution systems when the system is supplying oxy-fuel gas equipment.

For details for the requirements for oxy-fuel systems refer to BCGA CP 7 (48).

# DISTRIBUTION SYSTEMS

FIGURE 2




LEGEND

16. Flexible Hose
17. Flashback Arrestor
18. Pressure Relief Valve/Bursting Disc
19. Isolating Valve
20. Pressure Gauge
21. Analysis Point
22. Alarm

23. Isolating Valves
24. Filter
25. Flowmeter
26. Purge Valve
27. Outlet Isolating Valve
27A. Non-return Valve
27B. Flashback Arrestor
27C. Thermal Cut-off Valve
28. Outlet Point Pressure Regulator

27A, 27B and 27C can be combined in a single unit

NOTE: Any equipment downstream of the system above must be suitable for the pressure upstream or suitably protected.

# 5 DESIGN

## 5.1 General

The system shall be designed in accordance with an appropriate published design standard or code such as BS 1306 (15) or ASME B31.3 (60) or (for plastic piping see Appendix 10) and conform to the applicable requirements of the Pressure Equipment Regulations (4) and Pressure Systems Safety Regulations (5). For flammable and oxidising gases The Dangerous Substances and Explosive Atmosphere Regulations (DSEAR) (6) will apply, and a suitable and sufficient risk assessment will need to be produced. For flammable gases this will require the installation to be suitably zoned, and only equipment suitable for that zone shall be used within it. BS EN 60079 Part 10 (37) provides information on the zoning procedure.

Materials, which may be exposed to the gas stream, shall be compatible with the particular gas and conform to BS EN ISO 11114 Parts 1 & 2 (43). Recommended materials and cleanliness for specific gases are given in Appendices 1 - 9.

Pipe systems shall be designed to avoid mechanical damage and minimise external stresses. Pipework in ducts should conform to the requirements of BS 9999 (26) and BS 8313 (25). Pipework liable to external corrosion shall be suitably protected.

Pipework shall be designed for ease of cleaning and purging particularly in oxygen and nitrous oxide service: dead legs where foreign matter could accumulate should be avoided. Pipework should be as straight and direct as possible to avoid excessive pressure drop (and potential impingement points, e.g. bends, when conveying oxygen).

## 5.2 General safety

### 5.2.1 Safety distances

Supply systems should, where practicable, be sited outdoors or in a manifold room, which conforms to the following safety requirements and is used solely for housing manifolds. Where the supply system and the manifold are separately located the appropriate safety distances shall apply to both locations.

Safety distances are intended to:

a) protect personnel from exposure to dangerous atmospheres and to prevent fire enhancement in the event of a release of oxygen;

b) protect the installation from the effects of thermal radiation or jet flame impingement from fire hazards;

c) protect the installation from physical impact damage.

The safety distances are based upon industry standards as published by the British Compressed Gases Association, HSE guidance notes and upon calculations based on physical tests or upon computer modelling of minor releases. The safety distances given are not intended to protect against catastrophic failure of the installation.

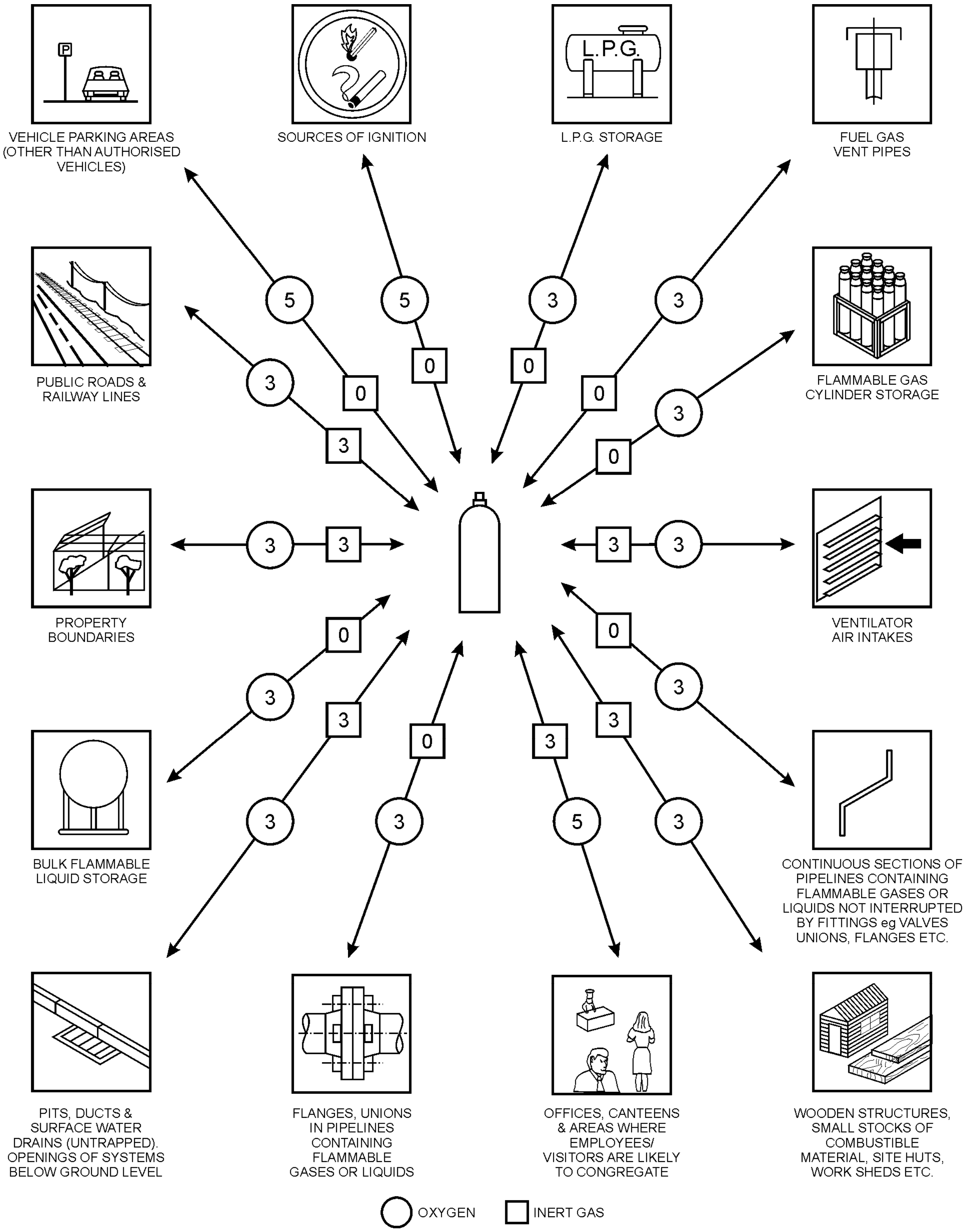
Safety distances are measured from any point on the system where in normal operation leakage or spillage could occur.

Shorter distances may be used if a site specific risk assessment in line with the European Industrial Gases Association (EIGA) methodology (using HSE fatality rates) indicates an acceptable level of risk.

Figure 3.1 displays the minimum safety distances for oxygen or inert gas manifolds and Figure 3.2 displays the minimum safety distances for flammable gas or LPG cylinder installations. The safety distances in Figures 3.1 and 3.2 shall be observed.

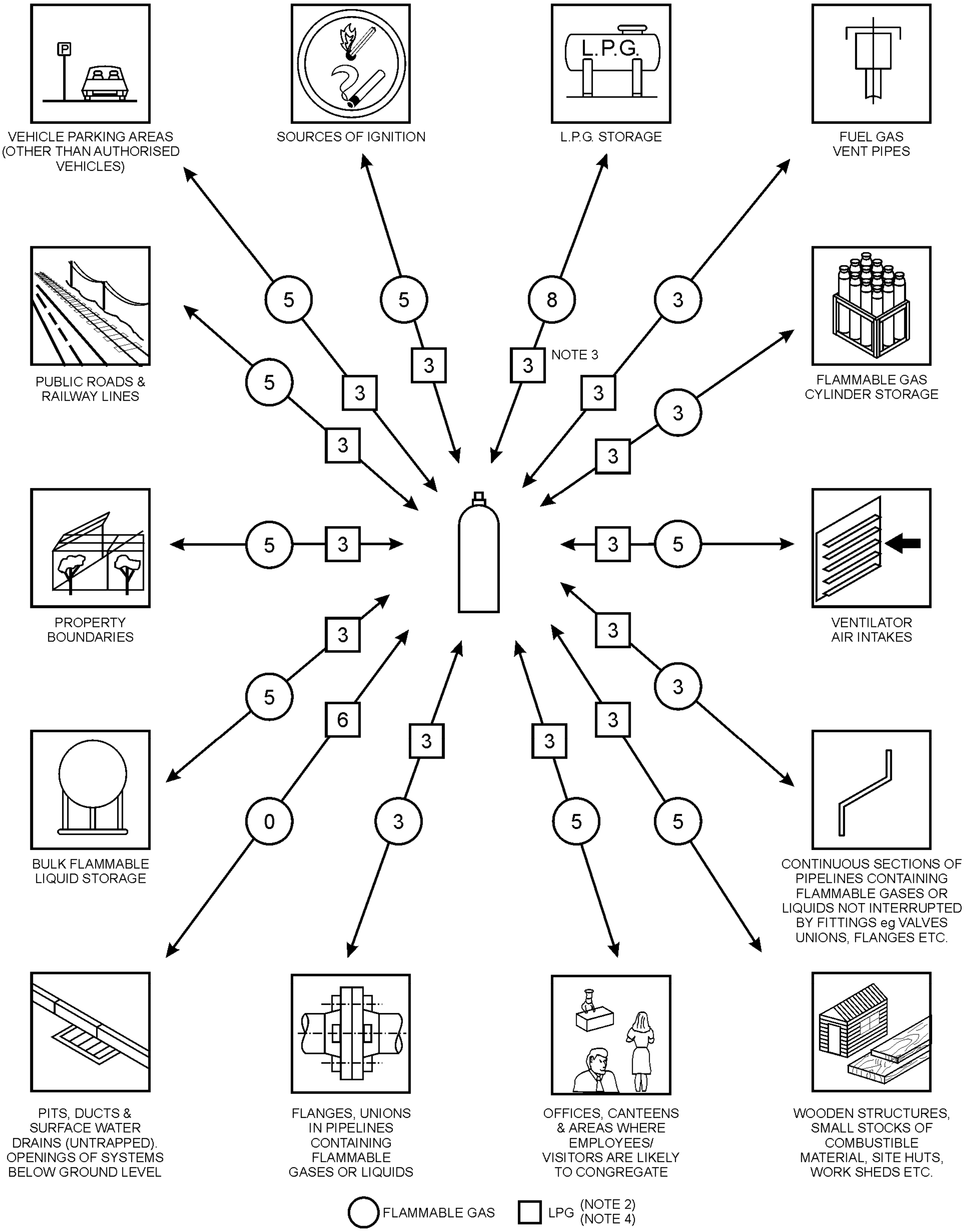
## Figure 3.1 – Minimum Safety Distances – oxygen or inert gas manifolds

Distance (in metres) between oxygen or inert gas manifolds and typical hazards.



## Figure 3.2 – Minimum Safety Distances – Flammable gas or LPG cylinder installations

Distance (in metres) between flammable gas or LPG cylinder installations and typical hazards.



NOTES on Figures 3.1 and 3.2:

1) The safety distances used for LPG are based upon those given in the UKLPG CP 1 - Bulk LPG storage at fixed installations (58) and UKLPG CP 7 Storage of full and empty LPG cylinders and cartridges (59). Where there is any discrepancy between the advice given here and the UKLPG Codes, the latter shall take precedence.

2) Where the quantity of LPG in cylinders is greater than 50 kg these shall be stored a minimum of 3 metres from bulk LPG installations of up to 5,000 litres and 7.5 metres from bulk storage of greater than 5,000 litres.

3) Where the quantity of LPG in cylinders is greater than 50 kg they should be not less than 7.5 metres from bulk liquid oxygen storage.

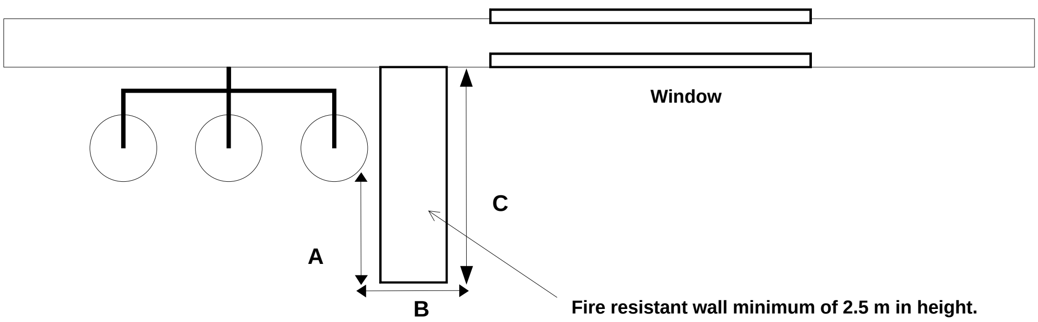
4) Storage of compressed flammable gas cylinders with up to 70 $Nm^3$ capacity shall be a minimum distance of 5 metres from bulk liquid oxygen storage and 8 metres where the quantity is in excess of this figure.

5) Safety distances for the siting of dissolved acetylene cylinders in relation to other gases and hazards are contained in BCGA CP 6 (47).

**How to use the Safety Distance Table**

The values in Figures 3.1 and 3.2 are all minimum distances. Where the required minimum safety distance cannot be achieved, permanent physical partitions or barriers may be used. The safety distance may then be measured around the ends of the wall to the installation as shown in Figure 4, A + B + C. Such partitions / barriers 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. See also HSE L136 DSEAR ACOP (9). Additionally, consideration shall be given to the density of the gas when considering safety distances.

**Figure 4 – Use of a partition to achieve an equivalent minimum safety distance**



### 5.2.2 Location of supply system

Installations should not be located where natural air ventilation is inhibited, examples of such locations are:

a) Inside structures with two or more sides and a roof;

b) Enclosed on three or more sides;

c) Below ground level or where there are pits, ditches and other ground depressions.

If any of the above apply the location is considered as indoors.

#### 5.2.2.1 Outdoor manifolds

Where the manifold is outside a building the following shall be observed:

Dependent upon the product and upon the security of the site, it may be sufficient to secure the manifold against a building wall. However where site security may be an issue, consideration should be given to the provision of a suitable wire mesh cage or similar well-ventilated security enclosure. Such installations shall also be in well-ventilated locations away from occupied areas and meet the safety distance criteria for the product to be used.

Where manifolds are mounted against or on building walls, the walls shall be of fire resistant materials to BS 476 (14).

Where security enclosures are used the gates should not be self-locking, should be outward opening and provide easy access and egress.

The base of the area beneath the manifold on which the cylinders, bundles, or cryogenic containers are located shall be of concrete or non-porous material and shall be oxygen compatible where applicable.

Surfaces shall be even and provide adequate drainage so that cylinders or containers do not stand in water. Any slope should be such that cylinders are stable. The base shall be of sufficient strength to take the weight of the cylinders, multiple cylinder packs or cryogenic containers which are to be used.

In some instances it may be necessary to erect fire walls in order to comply with the safety distances. When this is the case, outdoor installations shall not be enclosed by walls on more than 2 sides.

#### 5.2.2.2 Manifold rooms

Where a manifold is to be sited indoors, this should be in a specially constructed building or in an established building which conforms with these safety requirements. Where manifolds are installed in an existing building, they should be separated from the rest of the building by means of a wall built to roof level, of fire resisting material to BS 476 (14) and one wall should be an outside wall. Other than for inert products, the walls of manifold rooms should be constructed of fire resistant materials and the floor of concrete or a similar inorganic material. The room should have a suitable access door designed to allow easy level access for cylinder movements and ideally have a second emergency escape door. One of these doors should be on an outside wall.

NOTE: The use of fire resistant cabinets for cylinder manifolds is the subject of a BCGA statement given at Appendix 11.

Two sides of the room should be open, preferably opposite sides. It is acceptable practice to have one wall in wire mesh incorporating the entrance doors and to have high and low level ventilation in the opposite wall. However where the room is part of an existing building, the ventilation must be arranged such that it is not into the building.

The room must be well ventilated to prevent the build up of gases if leakage should occur and where different gases are used in the same room, both high and low level ventilation may be required.

The room shall have sufficient lighting to enable safe handling, product identification and operation of the system.

Where relief valves or bursting discs are fitted to manifolds, the outlets shall be piped away to a safe area. The sizing of the relief device outlet pipe shall be designed to minimise any back pressure during discharge in accordance with the relief device manufacturer's recommendations. The outlet of any vent line, or outlet line fitted to a relief device shall discharge into a safe area, which shall be construed as areas where gases may be discharged safely without creating an asphyxiant, flammable or oxygen enriched environment or where venting gas could impinge on materials or in proximity to people such as to create a hazard. Vent outlet points should therefore be remote from where people normally pass or gather, and not discharge towards windows, doors, air intakes or other hazards identified in the safety distances table. Consideration shall be given to the siting of an appropriate warning notice.

The number of cylinders in the room should be the minimum necessary for the operation and safety distances between different types of gases must be observed.

Where flammable gas manifolds are installed, electrical systems in the manifold room shall be in accordance with the recommendations of BS EN 60079 (36).

Heating should preferably be by steam or hot water.

The installation shall be clearly identified with the product name and hazards as per the requirements of The Health and Safety (Safety Signs & Signals) Regulations (2), either on the outside of a manifold room or adjacent to an outside installation.

The roof should be designed to prevent any build up of lighter than air gases and where a pitched roof is used this should be vented at the apex. Both entrance and escape doors (where fitted), should open outwards, should not be self locking and should provide easy means of escape from within at all times.

The main problem related to the siting of manifolds within a building is the inventory of gas within the cylinders, which in the event of a leak could create an asphyxiant, flammable or oxygen enriched atmosphere. However there are circumstances where it may be acceptable to position manifolds inside buildings where the volume of the building is such that there is no possibility of an asphyxiant or oxygen enriched atmosphere occurring.

Where such a course of action is being considered, a risk assessment shall be carried out to determine the level of risk which may occur in such an area in the event of a leak i.e. asphyxiant, flammable, oxygen enriched atmosphere. The BCGA accepted limits of oxygen concentration in the atmosphere for normal working are above 19.5 % and below 23.5 %. For flammables a level of 25 % of the lower explosive limit should trigger an alarm. For $CO_2$ the level accepted for normal working is less than 5000 ppm (0.5 %). (The risk assessment should also consider how cylinders could be removed from the building in the event of an incident).

For gaseous products this may be calculated as follows:

$$C_{ox} = \frac{100\ V_o}{V_r}$$

Where:

| | | |
|---|---|---|
| $C_{ox}$ | = | oxygen concentration |
| $V_o$ | = | $0.21\ (V_r - V_g)$ for argon, nitrogen, helium, nitrous oxide and carbon dioxide |
| $V_o$ | = | $0.21\ (V_r - V_g) + V_g$ for oxygen |
| $V_r$ | = | room volume $m^3$ |
| $V_g$ | = | maximum gas release $m^3$ |

An alternative method is to consider the number of air changes which would be required to maintain the level of oxygen in a room within acceptable limits in the event of a given rate of leakage - this may be more appropriate for cryogenic containers.

$$C_t = 0.21 + \left[ \frac{0.21n}{\left( \frac{L+n}{Vr} \right)} - 0.21 \right] \left[ 1\text{-}e^{-t/m} \right]$$

Where:

| | | |
|---|---|---|
| $C_t$ | = | oxygen concentration at time t |
| L | = | gas release $m^3/h$ |
| $V_r$ | = | room volume $m^3$ |
| n | = | air changes per hour |
| t | = | time gas has flowed in hours |
| m | = | $\frac{Vr}{L + n\,Vr}$ |

and for long periods (t tending to infinity):

$$C_\infty = \frac{Vr \times 0.21 \times n}{L + (Vr \times n)} \quad \text{approximately}$$

### 5.2.3 Example calculations

#### 5.2.3.1 Example calculation 1A

One nitrogen 50 litre cylinder charged to 200 bar being used in a workplace with a free air volume of 75 $m^3$.

$Vr = 75\ m^3$

$$\text{Volume of gas in cylinder} = \frac{50 \times 200}{1000} = 10\ m^3$$

$$V_O = 0.21(75 - 10) = 13.65\ m^3$$

$$\text{Resulting oxygen concentration } (C_{ox}) = \frac{100 \times 13.65}{75} = 18.2\ \%$$

This oxygen concentration is below the minimum workplace concentration for normal working recommended by the BCGA. However, the instantaneous release of the whole contents of a compressed gas cylinder is an almost inconceivable event, and not foreseeable as part of normal working. Thus specific preventative measures are unlikely to be required in this case.

#### 5.2.3.2 Example calculation 1B

One 6.35 kg (14 lb) carbon dioxide cylinder being used in a workplace with a free air volume of 75 $m^3$.

$Vr = 75\ m^3$

$V_O = 0.21(75-((6.35 \text{ x } 535)/1000)) = 0.21(75-3.4) = 15.0\ m^3$

Resulting oxygen concentration ($C_{ox}$) = (100 x 15)/75 = 20%

This oxygen concentration is above the minimum recommended by the BCGA. However carbon dioxide is mildly toxic and therefore the HSE have defined a workplace exposure limit of 0.5 % averaged over 8 hours, with a maximum exposure of 1.5 % for short periods of 15 minutes, refer to HSE EH 40 (11).

The volume of carbon dioxide from this 6.35 kg cylinder could produce a concentration of 4.5 % in case of complete loss via, for example, a bursting disc failure. This would produce a dangerous atmosphere and preventive measures are necessary.

#### 5.2.3.3 Example calculation 2

An inert gas is being used in a work place with a free air volume of 18 m$^3$, the gas flow rate is 1.1 m$^3$/h, the air changes are 0.4 per hour and the time taken to complete the job is 2 hours.

To establish the effect of this activity on the workplace atmosphere after 2 hours the following formula is used:

$$Ct \quad = \quad 0.21 + \left[ \frac{0.21n - 0.21}{\frac{L+n}{Vr}} \right] \left[ 1 - e^{-t/m} \right]$$

where:

$C$ = oxygen concentration at time $t$, which can be multiplied by 100 to give the % concentration

$L$ = 1.1

$Vr$ = 18

$n$ = 0.4

$t$ = 2

$$m \quad = \quad \frac{Vr}{L + nVr} = 2.17$$

Ct = 0.19324

This is the concentration of the oxygen in the air.

The oxygen concentration in the workplace has dropped to 19.324 %, which is above the minimum recommended by the BCGA and above the level where the BCGA recommends evacuation of the workplace (18 %), therefore preventative measures will probably not need to be taken.

#### 5.2.3.4 Example calculation 3

Consider a 50 litre, 200 bar cylinder of hydrogen in a room of internal volume 75 m$^3$. The volume of gas contained in the cylinder is 8.796 m$^3$, measured at 1.013 bar and 15 °C.

The concentration of hydrogen in the room is thus

8.796 / 75 x 100 % = 11.7 %

As in example calculation 1A the instantaneous release of the complete contents of the cylinder is not normally a reasonably foreseeable event, however the result is over 10 times the suggested maximum acceptable gas concentration (25 % of LEL, which is for hydrogen in air 4 %, giving a maximum allowable concentration of 1 %). There is therefore sufficient gas to cause a dangerous situation, and a detailed risk assessment will be needed to decide how to make the situation acceptable, for example by defining the room as a zoned area, requiring that all sources of ignition and electrical equipment be designed accordingly.

## 5.3 Use points

Where there is a perceived risk at the use point from a gas escape a risk assessment shall be conducted to establish necessary controls.

## 5.4 Distribution pipework design

### 5.4.1 Pressure drop

For most conditions and gases within the scope of this Code, pressure drop (at 15 $^{o}$C) can be estimated from the formula:

$$\Delta P = P_1 - \sqrt{P_1^{\,2} - \frac{32\,Q^2\,L\,S_g}{d^5}}$$

where:

| | | |
|---|---|---|
| $\Delta P$ | = | pressure drop bar |
| $P_1$ | = | inlet pressure bar absolute |
| Q | = | flow $m^3$/h measured at 15 $^{o}$C & 1013 mbar |
| L | = | pipe length m |
| $S_g$ | = | specific gravity air = 1 |
| d | = | internal diameter of pipe mm |

Pressure drop will be increased due to fittings and components installed in the pipework. The usual method of calculating pressure drop, due to fittings and components, is to increase theoretically the pipe length to account for the fittings as shown in Table 3.

**Table 3 – Calculating pressure drop due to fittings and components installed in pipework**

| | Equivalent length of straight pipe (m) | | | | | |
|---|---|---|---|---|---|---|
| **Pipe size mm - nominal** | **Valves (Wide open)** | | | **Fittings** | | |
| | **Ball** | **Globe or Diaphragm** | **Angle** | **Tee (Through)** | **Tee (Branch)** | **Elbow** |
| **10** | 0. 3 | 4. 0 | 2. 5 | 0. 2 | 0. 9 | 0. 4 |
| **12** | 0. 3 | 4. 0 | 2. 5 | 0. 2 | 0. 9 | 0. 4 |
| **15 / 16** | 0. 3 | 6. 0 | 3. 1 | 0. 3 | 1. 0 | 0. 5 |
| **20 / 22** | 0. 6 | 6. 0 | 4. 0 | 0. 6 | 1. 9 | 0. 7 |
| **25 / 28** | 0. 9 | 9. 0 | 5. 0 | 0. 6 | 1. 9 | 0. 9 |
| **42** | 1.2 | 14.0 | 7.5 | 0.9 | 3.0 | 1.2 |
| **54** | 1.4 | 16.0 | 9.0 | 1.1 | 3.5 | 1.4 |

Allowance should be made at the design stage for future extensions.

NOTE: The calculations for pressure drop are applicable to metallic piping only and provide indicative values.

### 5.4.2 Velocity

For materials of construction of oxygen systems, the velocity of the gas must be kept below a defined value. See Appendix 1.

For most gases and conditions covered by this code, velocity may be calculated using the following formula:

$$V = \frac{358\ Q}{D^2(P + 1.013)} \quad \text{m/s}$$

where:

Q is the gas flow-rate in cubic metres per hour measured at 15 $^{o}$C, 1013 mbar

D is the internal diameter of the pipe: mm

P is the inlet pressure: barg

# 6 MATERIAL & COMPONENT SELECTION

## 6.1 Materials of construction

For the specific gases covered by this code the suitable materials are detailed in Appendices 1 to 9.

## 6.2 Flexible hose assemblies

Flexible hose assemblies shall have end fittings permanently attached and where used on flammable gas systems be electrically conductive with a resistance not exceeding $10^6$ ohms to give protection against electrostatic charging.

They shall be suitable for the design pressure, compatible with the service gas and the length and diameter shall be kept to a minimum. Where the pressure exceeds 40 barg anti-whip wires shall be fitted to prevent injury to personnel in the event of a hose failure.

Hose assemblies shall conform to BS EN ISO 14113 (44) or an equivalent standard.

## 6.3 Pigtail

Typically this is made from 90 / 10 cupro / nickel or other materials suitable for the gas and pressure.

## 6.4 Manifold

Typically this is made from 90 / 10 cupro / nickel or other materials suitable for the gas and pressure.

## 6.5 Regulators

Regulators shall be suitable for the particular gas service and it is recommended that they be suitably labelled. They shall be suitable for the design pressure and flow rate and shall comply with European or British Standards where appropriate (e.g. BS EN ISO 7291 (42), BS EN ISO 2503 (39)).

## 6.6 Pressure gauges

Pressure gauges shall conform to BS EN ISO 5171 (41) or BS EN 837 (29) for the operating requirements of the particular gas service.

## 6.7 Pressure relief devices

Pressure relief valves shall conform to BS EN ISO 4126 (xx) or an equivalent design standard and shall be so sized that with the valve fully open the pressure in the system cannot exceed the design pressure. A momentary over-pressure not exceeding 10 % of the set pressure is permitted to allow for the lifting characteristics of the valve.

Bursting discs shall conform to BS EN ISO 4126 (40) or an equivalent design standard. When fitted alone bursting discs shall be selected so that the pressure rating taking into account maximum tolerance, will not allow the pressure in the system to exceed the design pressure by more than 10 %.

Pressure relief devices shall be properly secured. Relief device outlets shall be sited to relieve in a safe area. Where vent pipes are used, they shall be adequately sized to relieve the flow rate, be securely anchored to prevent movement and sited to discharge to a safe place.

Certification for safety devices shall be provided by the supplier.

### 6.8 Isolation valves

Isolation valves shall be designed for positive shut-off and should be suitably identified by type for pressure rating, direction of flow and gas service.

Specific gas service restrictions are detailed in Appendix 1-9.

Isolation valves should be fitted at strategic points on all main and branch lines so as to be readily accessible for emergency isolation.

### 6.9 Non-return valves

Non-return valves should be capable of passing the required flow rate without oscillation or excessive pressure drop.

Consideration shall be given to the required performance capability of a non-return valve with respect to the specific application including cracking pressure, seat leakage and reseating pressure. This is especially important where cross or backfeed contamination can occur. Where non-return valves are used, for example in multi-cylinder manifolds, primarily as safety devices to prevent high pressure gas flowing back through open-ended flexible hoses, absolute leak-tightness against back flow may not be required.

### 6.10 Flashback arrestors

Flashback arrestors shall be suitable for the required flow requirements and conform to BS EN 730 (28).

### 6.11 Filters

Filters should be installed to protect equipment from particles, and should be compatible with gas and pressure. Additional consideration shall be given to the filtration requirements of oxygen systems to prevent the possibility of loose particles forming ignition sources through impingement or frictional heating.

## 7. CONSTRUCTION, INSTALLATION AND TEST

### 7.1 Pipe bends

Bends shall have the same design strength as straight pipe sections.

Pipes should have a minimum bend radius of 3D (where D is the nominal pipe bore). Fabricated bends shall show no signs of buckling, cracking or other defects.

### 7.2 Flanges and fixings

Flanges shall conform to a recognised standard such as BS EN 1759 (31) or BS EN 1515 (30) in respect of material, dimensions and drilling and be suitable for the duty for which they are installed.

Nuts and bolts shall conform to a recognised national standard such as BS EN 1515 (30) and be suitable for the duty for which they are installed. Bolts and stud bolts shall extend completely through the nuts.

### 7.3 Jointing materials

The design shall specify the joint sealing material to be used. Jointing materials shall be capable of withstanding the maximum pressure and maintaining their chemical and physical properties at any temperature which may be experienced in service.

All types of jointing material shall be suitable for the particular gas service.

PTFE tape for use in oxygen service shall be of degreased quality to BS 7786 (24). Asbestos based materials shall not be used.

### 7.4 Pipe fittings

Pipe fittings shall be capable of withstanding the system design pressure and shall be compatible with the service gas.

### 7.5 Compression fittings

Only compression fittings designed and approved for the specific gas application shall be used (this excludes domestic plumbing fittings). Compression fittings should not be used in systems where they may be exposed to wide temperature variations. They should be confined to the installation of instrument lines and similar small bore connections up to 15 mm. Where this method of jointing is used, the requirements of BS 8313 (25) must still be observed in relation to routing of pipework through ducts, roof voids and similar confined spaces. It is essential that manufacturer's installation instructions be followed when compression fittings of any type are used.

### 7.6 Pipe jointing

Pipes shall be jointed by one of the following techniques:

a) Carbon steel - welded, bronze welded, flanged, screwed or compression fittings.

b) Copper and copper alloys - brazed, bronze welded, flanged, screwed, compression fittings. Soft-soldered joints shall not be used.

c) Stainless steel - welded, brazed, flanged, screwed compression fittings.

d) Plastic varies according to the type of material, but may be solvent-welded, screwed, fusion-welded, flanged, hose fittings and clips, push-in or compression fittings.

Jointing techniques not mentioned above shall be used only after detailed evaluation and risk assessment.

## 7.7 Jointing techniques

### 7.7.1 Welding

All welding shall be made to approved procedures of which the following are recommended:

| | |
|---|---|
| BS 1821 (17) | Specification for Class 1 oxy-acetylene welding of ferritic steel pipework for carrying fluids.<br><br>NOTE: Withdrawn. |
| BS 2633 (18) | Specification for Class 1 arc welding of ferritic steel pipework for carrying fluids. |
| BS 2640 (19) | Specification for Class II oxy-acetylene welding of carbon steel pipework for carrying fluids.<br><br>NOTE: Withdrawn. |
| BS 2971 (20) | Specification for Class II arc welding of carbon steel pipework for carrying fluids. |
| BS 4872 (21) | Specification for approval testing of welders when welding procedure approval is not required. |
| BS EN 287 (27) | Qualification test of welders. Fusion welding.. |
| BS EN ISO 15612 (45) | Specification and qualification of welding procedures for metallic materials. Qualification by adoption of a standard welding procedure. |
| ASME Section IX (61) | Boiler and Pressure Vessel Code, Section IX. Welding and brazing qualifications. |

### 7.7.2 Brazing

Joints shall be made with the appropriate brazing alloy and flux, where this is appropriate and generally to BS EN 13134 (34) for BS 1306 (15) piping systems or ASME Section IX (61) for ASME B31.3 (60) process piping. Pipe ends shall be square cut with full penetration into the end fitting and a minimum wetted area of 70 % or in accordance with the brazing procedure.

Brazers shall be approved in accordance with BS EN 13133 (33).

In cases where flux residues are not acceptable e.g. medical, some laboratory and food applications, copper phosphorus rod may used for fluxless brazing of copper to copper using a suitable purge.

### 7.7.3 Screw threads

Screw threads shall conform to BS 21 (13) or BS EN 10226 (32), as appropriate, where the pressure seal is made on the thread and to BS EN ISO 228 (38) where the seal is not made on the thread. Threads shall be clean cut and the calculated strength of the threaded joints shall be adequate for the pressure and other service loading of the pipework in which they are installed. The number of joints shall be kept to a minimum.

NOTE: Taper and parallel threads, and threads of different forms shall not be mismatched.

PTFE tape shall only be used on taper threads, it should only be applied sparingly and start at least one thread back from the start of the thread form. Under no circumstances should thread tape be in contact with the gas stream.

## 7.8 Supports

Supports shall be capable of supporting the pipe system without causing distortion. Supports shall also be adequate for the concentrated loads imposed by valves and risers and for axial loading due to expansions/contractions and the pressure of the fluid. As a guide to the frequency of pipe supports the following would normally be adequate for metallic pipework:

| Nominal pipe size (mm) | Support spacing (m) |
|---|---|
| Up to 15 | 1. 5 |
| 22 to 28 | 2. 0 |
| 35 to 54 | 2. 5 |

## 7.9 Routing

### 7.9.1 General

All pipework shall be adequately supported and protected where necessary from damage, vibration or corrosion.

Sections of pipework in buildings should be kept to the minimum reasonable practicable length. Where pipes have to be run inside buildings they should be run in well-ventilated rooms. Routings in enclosed spaces (roof and floor spaces, ducts, etc.) should be avoided. Where pipes have to be routed through enclosed spaces, they should be installed in accordance with BS 9999 (26) and BS 8313 (25).

BS 9999 (26) provides guidance for designers and is the fire safety code of practice for building design, management and use. This code recommends that gases should not be routed in or through ductwork provided for ventilation purposes.

BS 8313 (25) provides guidance relating to the accommodation of building services in ducts. This standard divides gas vapour and liquid pipework into groups according to the major risk associated with the pipework contents. BS 8313 (25) recommends that hazardous materials such as flammable, oxidising, toxic or corrosive gases or liquids should only be run in ducts when there is no safe practical alternative.

### 7.9.2 Routing in ducts

Where it is necessary to install flammable gas pipework in ducts the following precautions shall be taken:

a) Flammable gas pipework shall not be installed in the same duct as any other services other than cold water or steam.

b) The pipe shall be of non-combustible material with a melting point not lower than 800 °C.

c) The duct shall be well ventilated or by some other means it should be ensured that a hazardous atmosphere cannot develop within the duct.

d) There shall be no mechanical joints within the enclosed pipe run.

e) Joints shall be welded or brazed and strength tested in accordance with the requirements of Section 7.7.

f) Pipes carrying liquefied flammable gases should not be run in ducts unless the duct is filled with a crushed inert in-fill in order to reduce to a minimum the volume of any gas which may accumulate as a result of a leak.

Pipes conveying oxidising gases should only be run in ducts if the following precautions are taken:

g) The pipe shall be of non-combustible material with a melting point not lower than 800 °C.

h) The duct shall be well ventilated or by some other means it should be ensured that a hazardous atmosphere couldn't develop within the duct.

i) Joints shall be welded or brazed and strength tested in accordance with the requirements of Section 7.7.

j) Pipes carrying oxidising gases should not be exposed to any leakage of incompatible materials, e.g. from oil or flammable materials.

Inert gases or mixtures of these may be run in ducts if the following precautions are taken:

k) The duct shall be well ventilated or by some other means it should be ensured that a hazardous atmosphere cannot develop within the duct.

l) Joints shall be welded or brazed and strength tested in accordance with the requirements of Section 7.7.

m) Pipes carrying liquefied inert gases should not be run in ducts unless the duct is filled with a crushed inert in-fill in order to reduce to a minimum the volume of any gas which may accumulate as a result of a leak.

Where it is not possible to ventilate ducts, pipework shall be run within an outer, larger diameter pipe, (i.e. sheathed), both ends of the outer pipe being open to well-ventilated positions.

Routing of flammable, oxidising or inert services through cavities should be avoided where practicable, but, if this is necessary, the following requirements shall be observed:

n) Services should take the shortest practicable route through the cavity.

o) The use of high-integrity pipework, avoiding joints within the cavity is recommended. Where a pipe penetrates a fire resisting division or enclosure, the pipe shall be sleeved. The fire resistance of the material used for the sleeve shall be at least equal to that of the materials forming the cavity. The sleeve shall be sealed to the structure using suitable building materials and the pipe shall be sealed.

## 7.10 Underground routing

Pipework should only be installed underground where there is no alternative, e.g. in order to cross roads, railway lines or to enter buildings. Several different methods may be used:

a) Pipes installed on pipe racks or supports inside concrete or metal ducts, which may be closed by the use of masonry slabs or which may be covered using open grid covers.

b) Pipes laid in trenches and backfilled.

c) Pipes laid in trenches and encased in concrete.

### 7.10.1 General requirements

Flammable and oxidising gases should not be run in the same trench or duct unless:

a) The ventilation is adequate e.g. in a large ventilated duct.

or

b) The trench is back filled with an inert non corrosive material and the oxygen and flammable gas lines have a minimum separation distance of 500 mm.

or

c) The lines are encased in concrete and the minimum separation distance is 300 mm.

Inert gases may be run in the same trenches as either oxidising or flammable gases.

Piping shall be at least 50 mm away from any electrical power cables.

Mechanical joints shall not be used underground. Joints shall be welded or brazed and tested in accordance with Section 7.7. Flanges or other mechanical joints shall only be permissible when they are essential for assembly and disassembly. Where valves are used, they should be accessible from the surface (via a suitable access pit, e.g. concrete or brick lined) and be of a high integrity leak tight design. Where the piping is to be laid underground on private property under tarmac or grass areas where there is no likelihood of heavy traffic, trenches shall be at least 600 mm deep. Where the pipe is to be laid under a road, the trench shall be a minimum of 500 mm deep. Where subsidence may be a problem, consideration should be given to using concrete slabs or steel plates positioned on a bed of sand above the pipe.

Where the ground at the base of the trench is of irregular consistency, the depth of excavation should be increased by approximately 75 mm in order to allow the pipe to be laid on a bed of sand.

Pressure testing should take place prior to back-filling, although this is not essential if all joints and connections are left exposed for such tests. The backfill at the sides of the pipe and immediately above it should be of the same material as that used under the pipe. The initial cover of backfill over the pipe should be carried out by hand and compacted such that there is a good support between the sides of the pipe and the trench and a firm layer over the top of the pipe.

Where piping is to enter a building, the entry point should be above ground wherever this is practicable. Pipework shall not pass under the foundations of the building, under the base of a wall or under the footings. Where the pipework passes through the wall of the building, a metal sleeve shall be used and where appropriate, the same principles of construction used as if the pipework were passing through a cavity.

Plastic pipe work shall not be laid in chemically corrosive soils containing tars, oils or other acidic type residues. Manufacturers of such pipe should be consulted where there is any doubt.

## 7.11 Protection

### 7.11.1 Painting

Where painting is required, this should be done in accordance with manufacturers recommendations on clean, dry and rust-free surfaces.

### 7.11.2 Wrapping

For buried pipework or in corrosive atmospheres, a protective wrapping shall be applied. The protection shall be applied as a continuous wrap with sufficient overlap to prevent exposure of the pipe surface. Pipework laid in open trenches shall be painted where necessary. Wrapping shall be compatible with the service gas.

### 7.11.3 Cathodic protection

Alternatively, a cathodic protection system may be installed to counteract the corrosive nature of the terrain. This is usually installed by a specialist contractor and should take into account BS EN 60079 (36) or an equivalent standard.

## 7.12 Earth bonding electrical continuity etc.

Flammable gas manifolds and pipework shall be electrically earthed in accordance with the requirements of BS EN 60079 (36). Manifolds and pipework carrying other gases should be cross-bonded to earth in accordance with the recommendations of BS 7671 (23) which outlines the current Institution of Engineering and Technology (IET) Wiring Regulations.

## 7.13 Cleaning

Before erection, pipes, fittings and equipment shall be fully cleaned and degreased and cleanliness maintained thereafter. However, certain gases such as oxygen require special cleaning methods as indicated in the Appendices. Where this is the case, it is recommended that all pipework, valves and fittings exposed to the product are purchased from a supplier with the capability of cleaning to this standard. Alternatively specialist-cleaning companies may be used. Site cleaning of pipework should be limited to re-cleaning ends of pipework/valves and fittings which may have been contaminated during the system erection process.

Appropriate health and safety precautions shall be followed. Used solvent shall be recovered and disposed of in accordance with applicable environmental legislation.

Completed pipework shall be cleaned internally until all foreign matter is removed. This will normally be achieved by passing clean, dry, oil-free nitrogen or air through the pipework at high velocity.

## 7.14 Identification

According to the complexity of the installation and to the variety of gases conveyed, each pipe should be identified in accordance with BS 1710 (16) and BS 5499 (22).

Where the precise nature of the pipe content is important, a secondary identification should be superimposed on the basic identity either by written word, gas symbol or secondary colour.

## 7.15 Testing

### 7.15.1 General

Pressure gauges and safety devices may have to be removed from the system before testing. Safety devices will normally be tested prior to installation by the manufacturer. Parts which have been tested prior to installation may be excluded from the pressure test on the final inspection.

### 7.15.2 Pressure test

Particular equipment design codes will have specific pressure testing requirements, and the equipment may also be required to comply with any applicable national legislation i.e. The Pressure Equipment Regulations (4).

### 7.15.3 Types of pressure test

Proof pressure test. This test is carried out when the required thickness of all the pressure parts has not been accurately calculated or is in doubt. Proof pressure testing should only be carried out hydraulically and the pressure applied gradually until the specified test pressure is reached or until significant yielding of any part of the pressure equipment occurs. This is not normally applicable, as all components should be suitable for the design pressure.

Standard pressure test. This test is used when the required thickness of all pressure parts has been calculated, this test is carried out at a minimum of 1.1 times the design pressure or higher when specified by the applicable design code.

Leak test. This test may be performed at a pressure, at 90 % of the design pressure.

Functional test. This test is carried out using a suitable test medium at the working pressure, to check that the pressure equipment and its components function properly. It may include the actuation of moveable parts, such as the opening and closing of valves; this is normally done at the conclusion when protective devices etc. have been refitted.

### 7.15.4 Applicable pressure tests

New equipment. A standard and a functional pressure test.

Repaired or refurbished equipment. A leak test (as the equipment should have already had a standard pressure test when it was manufactured) and a function test.

### 7.15.5 Test medium

Equipment should be hydraulically tested wherever possible, as the energy released in the event of a failure compared with a pneumatic test is considerably lower.

Pneumatic testing should only be carried out when hydraulic testing is not practicable, for instance where the interior of the pressure equipment will be contaminated by the hydraulic test medium.

For hydraulic testing water with a chloride content of less then 50 ppm should be used.

For pneumatic testing helium or a helium / air mixture is used, since helium is a ‘searching’ gas and will leak from positions that a gas such as nitrogen will not.

#### 7.15.6 Determination of the test pressure

Test pressure is a function of the design pressure of the equipment.

For systems connected to a high pressure source, e.g. a compressed gas cylinder, the design pressure shall be the developed pressure of the cylinder.

For other systems it can either be at the design pressure of the lowest pressure rated component in the system or at the setting of a protective device protecting the system.

Whatever pressure test is to be performed and the fluid used a risk assessment shall be carried out.

Further guidance on pressure testing is given in HSE publication GS4, Safety in pressure testing (10).

#### 7.15.7 Pressure retention test

Where required the system may be pressurised to the maximum operating pressure for a period which is relative to the capacity of the system under test. After taking into account any changes in ambient conditions, the pressure variation of the system during this period will be measured. If this variation is acceptable the system may be commissioned; if not further leak checks will be required.

### 7.16 Commissioning

#### 7.16.1 Anti-confusion

Where, for any reason, cross-connection of the pipework is possible, the following anti-confusion check shall be made:

a) Isolate the pipework from all gas supplies except the one under test, then:

b) Check that gas is supplied at each outlet point of the pipework under test.

c) Ensure no gas is supplied into the system or from the outlet points of any other system

d) Prove each pipework supply and distribution system in turn with all other systems isolated.

#### 7.16.2 Purging into service

The total system may be purged with an inert gas before introducing the service gas systematically into the system. For small systems, purging may be carried out with the service gas.

#### 7.16.3 Service tests

Check non-return valves and stop valves for closure tightness and gland leakage.

Check manifold changeover valves for closure tightness and gland leakage. Automatic changeover devices should be checked for correct operation.

Check alarm and cut-off devices for correct operation and set pressure.

### 7.17 Precautions

Before connecting gas cylinders make sure that there are no particles of dirt in the cylinder outlet.

Carefully inspect the outlet and if there are any signs of dirt, blow it out with a jet of compressed air or wipe with a clean, oil free, lint free cloth.

Ensure that the cylinders to be connected are correctly identified for the system e.g. product and pressure.

Ensure that all equipment to be connected to the system is suitable for the maximum operating pressure that can be applied and the service gas.

Correct tools should be used to tighten cylinder connections and valves to avoid damage and over torque.

Always open valves **SLOWLY** when connected to the gas supply. An open valve should not be left less than half a turn from the fully open position.

### 7.18 Provision of information

In accordance with the Pressure Systems Safety Regulations (5) the designer, supplier or the employer of a person who installs, modifies or repairs a pressure system shall provide sufficient written information to enable the user of a pressure system to determine the safe operating limits within their responsibility. Such information may include the following;

a) Design Codes.

b) Process and Instrumentation Drawings (P&ID) or flowsheets.

c) Safe operating limits for pressure and temperature.

d) Design pressure and Design Temperature.

e) Operating Instructions (including emergency procedures).

f) Written Scheme of Examination.

g) Maintenance Instructions.

h) Test Certificates.

i) Declaration of conformity.

Appropriate information should be included in the handover documentation or operating instructions supplied to the user.

In the case of flammable or oxidising gas systems the user shall be advised of the need to carry out a risk assessment to comply with DSEAR (6).

## 8 USER OF THE PRESSURE SYSTEM

The following paragraphs give details of the duties of the user in relation to the operation, examination, repair and maintenance of the system and of the need for the user to obtain a written scheme of examination (if applicable) for the system and keep certain records. Further information relating to the Pressure Systems Safety Regulations (5) is given in the BCGA CP 23 (50) and the Pressure Equipment Regulations (4).

### 8.1 Operation - information and training

Suitable instructions shall be provided to indicate operation of controls and a system flowsheet / P& ID shall be available.

Hazard warning notices appropriate to the installation shall be clearly displayed together with telephone numbers for emergency contact.

The supplier shall provide the user with information on operating conditions and these shall not be changed such that safe working could be jeopardised: any change shall be approved by a competent authority.

All operators shall receive adequate instruction and training before operating manifolds and pipes.

### 8.2 Maintenance

Maintenance is required by the Pressure Systems Safety Regulations (5) to ensure equipment remains in a safe condition. It is the responsibility of the user to ensure that this is carried out.

Important differences exist between Maintenance and Written Scheme of Examination activities. The latter are formal assessments of the pressure system, or part of it, with regard to its ability to operate safely for a further specified period. The assessment only considers potential danger from the uncontrolled release of stored energy.

Maintenance covers a wide range of activities ranging from such items as servicing, adjustment, performance checks and painting through to routine safety inspections. The latter may partially overlap Written Scheme of Examination activities, but they are not as comprehensive and do not provide a complete assessment. As such they are not subject to formal postponement procedures and restrictive controls.

The maintenance schedule for a system should cover the following points as a minimum requirement:

### 8.2.1 Weekly inspection (by the user)

Check that:

a) Visually, equipment is in good order, is being correctly used and all the required equipment is fitted.

b) Manifold, framework and chains are in good condition.

c) Pigtails and flexible hoses are not corroded or damaged.

d) Valves shut off and open correctly.

e) Regulators are identified as being suitable for the gas and pressures and are not damaged.

f) The system is operating normally, i.e. report if the system is using more gas than normal, if there is an unusual drop in pressure or any indication of a malfunction or leak.

g) The manifold location is free from oil and combustible materials and the area is not used as a general storeroom.

### 8.2.2 Annual inspection (by a person with appropriate experience and knowledge)

Check that:

a) All repairs and modifications (including removals and additions of components) and extensions carried out conform to this Code of Practice.

b) Changes in the vicinity of the installation do not affect its operation or safety.

Examples are location of heat sources or burners, moving of machines or work places, occurrence of vibrations, use of pipework as an electrical earth or as a support for other items, proximity to electrical installations and to other piping systems.

c) There is adequate identification of above ground pipework and route markers for buried pipework.

d) The system is free from leaks by testing at the designated operating pressure.

e) Buried pipework is not visibly compromised in any obvious way.

f) Filters are in good condition and are not blocked. Clean or replace them where necessary.

### 8.3 Repair and modification

The user shall ensure that the employer of a person who installs, repairs or modifies a pressure system ensures that nothing about the way it is repaired or modified gives rise to danger, or otherwise impairs the operation of any protective device (e.g. pressure relief valve or bursting disc) or inspection facility.

All repairs and modifications must be carried out to the same design and construction standards as the original system, so as not to reduce its integrity. Full testing of the repaired or modified system will be required on completion (see Section 7.15).

System records, flowsheets / schematics, general layout drawings, operating instructions etc. will need to be updated following repair and modification. Consideration shall also be given to the need to amend the system safe operating limits.

### 8.4 Written Scheme of Examination

In order to conform with the requirements of the Pressure Systems Safety Regulations (5) the user of an installed system shall not allow it to be operated without a Written Scheme of Examination certified by a Competent Person.

The Written Scheme should cover the following items as a minimum requirement:

a) All protective devices.

b) All manifold pressure regulators (when they are a primary protective device).

c) All high pressure hoses and pigtails.

d) All pipework where a failure would give rise to danger.

Guidelines for Written Schemes of Examination are given in BCGA CP 23 (50).

### 8.5 Keeping of records

The following records shall be kept by the user (or the owner in the case where he has undertaken to examine and maintain the system):

a) The Written Scheme of Examination

b) The last report in accordance with the Written Scheme of Examination.

c) Previous reports if they assist in assessing whether the system is safe to operate.

d) Details of any repairs or modifications carried out.

e) Documents supplied under Section 7.18.

f) Agreement to postpone an examination and notification to the enforcing Authority.

g) Details of any out of service periods and storage conditions (where appropriate).

These records shall be kept either at the premises where the equipment is installed or at the office of the user or owner when applicable. The records may be kept within a computer system as long as a printed copy can be produced when required.

### 8.6 The competent person

The Pressure Systems Safety Regulations (5) define duties for the 'Competent Person' in three distinct functions, i.e.:

a) Advising the user on the scope of the Written Scheme.

b) Drawing up or certifying Written Schemes of Examination.

c) Carrying out examinations under the Scheme.

The 'Competent Person' may be either:

d) A user Company with its own in-house inspection department.

e) An inspection organisation providing such services.

f) A partnership of individuals.

g) A self employed person.

The HSE ACOP L122, Safety of pressure systems (8) defines the level of corporate membership, experience, specialist services and organisation required for the Competent Person drawing up or certifying Written Schemes of Examination for Minor, Intermediate and Major Systems.

Member Companies of BCGA are able to provide advice on the systems used within the gases industry.

## 9 REFERENCES *


**Legislation:**

| | | |
|---|---|---|
| 1 | | Gas Act 1986 |
| 2 | SI 1996 No 341 | The Health and Safety (Safety Signs and Signals) Regulations 1996. |
| 3 | SI 1998 No 2451 | Gas Safety (Installation and Use) Regulations 1998 |
| 4 | SI 1999 No 2001 | The Pressure Equipment Regulations 1999. |
| 5 | SI 2000 No 128 | Pressure Systems Safety Regulations 2000. |
| 6 | SI 2002 No 2776 | The Dangerous Substances and Explosive Atmospheres Regulations 2002. |

**Health & Safety Executive publications:**

| | | |
|---|---|---|
| 7 | L 56 | Safety in the installation and use of gas systems and appliances. Gas Safety (Installation and Use) Regulations 1998. Approved Code of Practice and guidance. |
| 8 | L 122 | Safety of pressure systems. |
| 9 | L 136 | Dangerous Substances and Explosive Atmospheres Regulations. Approved Code of Practice and Guidance. Control and mitigation measures. |
| 10 | HSE Guidance Note GS4 | Safety in pressure testing, 1998. |
| 11 | HSE EH 40 | Workplace exposure limits. |

**Department of Health publications:**

| | | |
|---|---|---|
| 12 | HTM 02-01 | Health Technical Memorandum. Medical gas pipeline systems |

**Standards:**

| | | |
|---|---|---|
| 13 | BS 21 | Specification for Pipe Threads for Tubes and Fittings where pressure-tight joints are made on the threads. |
| 14 | BS 476 | Fire tests on building materials and structures. |
| 15 | BS 1306 | Specification for copper and copper alloy pressure piping systems. |

| | | |
|---|---|---|
| 16 | BS 1710 | Specification for Identification of Pipelines and Services. |
| 17 | BS 1821 | Specification for Class 1 oxyacetylene welding of ferritic steel pipework for carrying fluids.<br><br>NOTE: This standard has been withdrawn as it is no longer common industry practice to use oxy-acetylene welding for pipework. |
| 18 | BS 2633 | Specification for Class 1 arc welding of ferritic steel pipework for carrying fluids. |
| 19 | BS 2640 | Specification for Class II oxyacetylene welding of carbon steel pipework for carrying fluids.<br><br>NOTE: This standard has been withdrawn as it is no longer common industry practice to use oxy-acetylene welding for pipework. |
| 20 | BS 2971 | Specification for Class II arc welding of carbon steel pipework for carrying fluids. |
| 21 | BS 4872 | Specification for approval testing of welders when welding procedure approval is not required. |
| 22 | BS 5499 | Safety signs, including fire safety signs. |
| 23 | BS 7671 | Requirements for electrical installations. IET Wiring Regulations. |
| 24 | BS 7786 | Specification for unsintered PTFE tape for general use. |
| 25 | BS 8313 | Code of Practice for accommodation of building services in ducts. |
| 26 | BS 9999 | Code of Practice for fire safety in the design, management and use of buildings. |
| 27 | BS EN 287 | Qualification test of welders. Fusion welding. |
| 28 | BS EN 730 | Gas welding equipment. Safety Devices. |
| 29 | BS EN 837 | Pressure gauges. |
| 30 | BS EN 1515 | Flanges and their joints. Bolting. |
| 31 | BS EN 1759 Part 1 | Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, class-designated. Steel flanges, NPS 1/2 to 24. |

| | | |
|---|---|---|
| 32 | BS EN 10226 | Pipe threads where pressure tight joints are made on the threads. Taper external threads and parallel internal threads. Dimensions, tolerances and designation |
| 33 | BS EN 13133 | Brazing. Brazer approval. |
| 34 | BS EN 13134 | Brazing. Procedure approval. |
| 35 | BS EN 14470-2 | Fire safety storage cabinets. Safety cabinets for pressurised gas cylinders |
| 36 | BS EN 60079. | Explosive atmospheres. |
| 37 | BS EN 60079. Part 10 | Explosive atmospheres. Classification of areas. Explosive gas atmospheres. |
| 38 | BS EN ISO 228 | Pipe threads where pressure-tight joints are not made on the threads. |
| 39 | BS EN ISO 2503 | Gas welding equipment – Pressure regulators and pressure regulators with flow-metering devices for gas cylinders used in welding, cutting and allied processes up to 300 bar (30 MPa). |
| 40 | BS EN ISO 4126 | Safety devices for protection against excessive pressure.<br>Part 1: Safety valves<br>Part 2: Bursting disc safety devices. |
| 41 | BS EN ISO 5171 | Gas welding equipment. Pressure gauges used in welding, cutting and allied processes. |
| 42 | BS EN ISO 7291 | Gas welding equipment. Pressure regulators for manifold systems used in welding, cutting and allied processes up to 30 MPa (300 bar). |
| 43 | BS EN ISO 11114 Parts 1 and 2 | Transportable gas cylinders. Compatibility of cylinder and valve materials with gas contents.<br>Part 1: Metallic materials.<br>Part 2: Non-metallic materials. |
| 44 | BS EN ISO 14113 | Gas welding equipment. Rubber and plastic hose and hose assemblies for use with industrial gases up to 450 bar (45 MPa). |

**British Compressed Gases Association publications**

| | | |
|---|---|---|
| 46 | BCGA CP 5 | The design and construction of manifolds using acetylene gas from 1.5 bar to a maximum working pressure of 17 bar. |

| | | |
|---|---|---|
| 47 | BCGA CP 6 | The safe distribution of acetylene in the pressure range 0 -1. 5 bar. |
| 48 | BCGA CP 7 | The safe use of oxy-fuel gas equipment (individual portable or mobile cylinder supply). |
| 49 | BCGA CP 18 | The safe storage, handling and use of special gases in the micro-electronics and other industries. |
| 50 | BCGA CP 23 | Application of the Pressure Systems Safety Regulations 2000 to industrial and medical pressure systems installed at user premises. |
| 51 | BCGA CP 33 | The bulk storage of gaseous hydrogen at users' premises. |
| 52 | BCGA GN 2 | Guidance for the storage of gas cylinders in the workplace. |
| 53 | BCGA GN 3 | Safe cylinder handling and the application of the manual handling operations regulations to gas cylinders. |
| 54 | BCGA GN 10 | Implementation of EIGA carbon dioxide standards. |

**European Industrial Gases Association publications:**

| | | |
|---|---|---|
| 55 | EIGA IGC Doc 13/12 | Oxygen pipeline and piping systems. |
| 56 | EIGA IGC Doc 33/06 | Cleaning of equipment for oxygen service – guideline. |
| 57 | EIGA IGC Doc 42/04 | Flexible connections in high pressure gas systems |

**UKLPG publications**

| | | |
|---|---|---|
| 58 | CP 1 | Bulk LPG storage at fixed installations. |
| 59 | CP 7 | Storage of full and empty LPG cylinders and cartridges. |

**American Society of Mechanical Engineers (ASME) publications**

| | | |
|---|---|---|
| 60 | ASME B31.3 | Process Piping. |
| 61 | ASME - Section IX | ASME Boiler and Pressure Vessel Code, Section IX: Welding and Brazing Qualifications. |

Further information can be obtained from:

| | |
|---|---|
| Health and Safety Executive | www.hse.gov.uk |
| HSE Books | www.hsebooks.co.uk |
| HMSO | www.hmso.gov.uk |
| European Industrial Gases Association (EIGA) | www.eiga.eu |
| British Compressed Gases Association (BCGA) | www.bcga.co.uk |
| The United Kingdom LPG Association (UKLPG) | www.uklpg.org |
| Institution of Engineering and Technology (IET) | www.theiet.org |
| American Society of Mechanical Engineers (ASME) | www.asme.org |

**OXYGEN**

## 1 GENERAL DATA

| | |
|---|---|
| Chemical symbol | $O_2$ |
| Flammable / non-flammable | Non-flammable (see Clause 3. 1) |
| Lighter / heavier than air | Slightly heavier |
| Colour | Colourless |
| Odour | Odourless |
| Taste | Tasteless |
| Toxicity | Non-toxic |
| Corrosive | Non-corrosive (in absence of moisture) |

## 2 RECOMMENDED MATERIALS

NOTE: Up to 230 bar. At pressures higher than 230 bar materials may require special consideration. Refer to the gas supplier.

| | |
|---|---|
| Pipe | Copper / Copper alloy<br>Steel (restricted - see Clause 3. 3) |
| Jointing | Approved grades of:<br>PTFE<br>Compressed fibre |
| Copper washers, viton bonded seals | |
| Valves and other components | These require special consideration; refer to manufacturer. |

## 3 SPECIAL CONDITIONS

**3. 1** Oxygen is non-flammable but supports combustion vigorously, combining with all other elements except inert gases.

**3. 2** All readily combustible substances including oil, grease and organic solvents shall not be allowed to come into contact with oxygen or oxygen-containing equipment. Scrupulous cleaning, degreasing and freeing from solvents is of prime importance with oxygen. See EIGA IGC Document 33/06 (56).

**3. 3** For pipework made of ferrous materials, (e.g. stainless steel, carbon steel) the gas velocity shall be contained within limited values. The recommended limiting velocity for oxygen in ferrous distribution pipework is 15 m/sec maximum at 20 bar. See EIGA IGC Document 13/12 (55) for further information.

**3. 4** Where ball valves are used in oxygen systems other than as emergency shut off valves, extreme care shall be exercised in opening such a valve in order to prevent high velocity gas flows occurring where the line downstream of the valve is at a lower pressure than the line upstream of the valve. The other danger is of adiabatic compression occurring in the downstream system causing very high temperatures and possible ignition.

**3. 5** Rapid pressurisation of flexible hoses on oxygen manifolds (e.g. by fast opening of the cylinder valve may cause an ignition in a plastic lined hose or in the seat of the non-return valve because of adiabatic compression. In these circumstances adiabatic compression occurs because the change in pressure is so rapid that there is insufficient time for the heat which is generated to dissipate. Protective measures as described in EIGA IGC Document 42/04 (57) should be considered to prevent such an ignition resulting in a hose or valve failure with consequent risk of injury (e.g. provision of a suitable metallic `heat sink' at the hose end adjacent to the header).

## 4 SAFETY

**4. 1** Oxygen pipework should be separated from pipework containing flammable products and from sources of ignition to prevent the possibility of combustion occurring.

NOTE: Separation distances will vary according to the degree of precaution taken, e.g. ventilation, sleeving, separation barriers.

**4. 2** Oxygen pipework shall be separated by at least 50 mm from electrical systems.

**4. 3** Warning notices indicating “No Smoking, No Sources of Ignition” shall be displayed. Where the notice uses a pictorial symbol, then this shall be in accordance with The Health and Safety (Safety Signs & Signals) Regulations (2).

**4.4** Materials. For oxygen service the use of materials, lubricants and greases shall be restricted to oxygen compatible types only.

**NITROGEN**

## 1 GENERAL DATA

| | |
|---|---|
| Chemical symbol | $N_2$ |
| Flammable/non-flammable | Non-flammable |
| Lighter/heavier than air | Slightly lighter |
| Colour | Colourless |
| Odour | Odourless |
| Taste | Tasteless |
| Toxicity | Non-toxic (see Clause 4. 1) |
| Corrosive | Non-corrosive |

## 2 RECOMMENDED MATERIALS

| | |
|---|---|
| Pipe | Copper / Copper alloy<br>Steel<br>Plastic - within the limitations set out in Appendix 10. |
| Jointing | All commonly used materials are suitable. Except soft solder. |
| Valves and other components | All commonly-used materials are suitable. |

## 3 SPECIAL CONDITIONS

NIL

## 4 SAFETY

**4. 1** Although nitrogen is non-toxic, nitrogen-enriched atmospheres can cause asphyxiation through the depletion of oxygen.

**4. 2** Warning notices indicating “Inert Gas Storage” shall be displayed.

## ARGON

### 1 GENERAL DATA

| | |
|---|---|
| Chemical symbol | Ar |
| Flammable / non-flammable | Non-flammable |
| Lighter / heavier than air | Much heavier (see Clause 4. 3) |
| Colour | Colourless |
| Odour | Odourless |
| Taste | Tasteless |
| Toxicity | Non-toxic |
| Corrosive | Non-corrosive |

### 2 RECOMMENDED MATERIALS

| | |
|---|---|
| Pipe | Copper / Copper alloy.<br>Steel.<br>Plastic - within the limitations set out in Appendix 10. |
| Jointing | All commonly-used materials are suitable.<br>Except soft solder. |
| Valves and other components | All commonly-used materials are suitable. |

### 3 SPECIAL CONDITIONS

NIL

### 4 SAFETY

**4. 1** Although argon is non-toxic, argon-enriched atmosphere can cause asphyxiation through the depletion of oxygen.

**4. 2** Warning notices indicating “Inert Gas Storage” shall be displayed.

**4. 3** Argon is considerably heavier than air and will remain in low-lying places for long periods - this fact will influence the gas storage location and ventilation requirements.

**HELIUM**

## 1 GENERAL DATA

| | |
|---|---|
| Chemical symbol | He |
| Flammable / non-flammable | Non-flammable |
| Lighter / heavier than air | Much lighter |
| Colour | Colourless |
| Odour | Odourless |
| Taste | Tasteless |
| Toxicity | Non-toxic (see Clause 4. 1) |
| Corrosive | Non-corrosive |

## 2 RECOMMENDED MATERIALS

| | |
|---|---|
| Pipe | Copper / Copper alloy.<br>Steel.<br>Plastic - within the limitations set out in Appendix 10.<br>(Permeability should also be checked with the manufacturer). |
| Jointing | All commonly-used materials are suitable.<br>Except soft solder |
| Valves and other components | All commonly-used materials are suitable. |

## 3 SPECIAL CONDITIONS

Helium is an extremely penetrative gas which can leak through joints which have been proved leak tight with nitrogen, consequently more stringent jointing techniques such as back-brazing of screwed joints may be necessary.

## 4 SAFETY

**4. 1** Although helium is non-toxic, a helium-enriched atmosphere can cause asphyxiation through the depletion of oxygen.

**4. 2** Warning notices indicating “Inert Gas Storage” shall be displayed.

**4. 3** Helium is an extremely light gas which will readily collect at high level. Adequate ventilation in such places as the roof of a storage room is therefore necessary.

**HYDROGEN**

## 1 GENERAL DATA

| | |
|---|---|
| Chemical symbol | $H_2$ |
| Flammable / non-flammable | Flammable |
| Lighter / heavier than air | Much lighter |
| Colour | Colourless |
| Odour | Odourless |
| Taste | Tasteless |
| Toxicity | Non-toxic (see Clause 4. 1) |
| Corrosive | Non-corrosive |

## 2 RECOMMENDED MATERIALS

| | |
|---|---|
| Pipe | Copper / Copper alloy<br>Steel (see Clause 3. 2) |
| Jointing | All commonly-used materials are suitable.<br>Except soft solder |
| Valves and other components | All commonly-used materials are suitable (see Clause 3. 2) |

## 3 SPECIAL CONDITIONS

**3. 1** Hydrogen is an extremely penetrative gas which can leak through joints which have been proved leak tight with nitrogen, consequently more stringent jointing techniques such as back-brazing of screwed joints may be necessary.

**3. 2** Although most commonly used materials are suitable with hydrogen, the problem of embrittlement under cyclic conditions with steel must be considered especially at elevated temperatures and pressures.

**3. 3** The use of bursting discs is not recommended on hydrogen systems.

## 4 SAFETY

**4. 1** Although hydrogen is non-toxic, a hydrogen-enriched atmosphere can cause asphyxiation through the depletion of oxygen.

**4. 2** Hydrogen vent lines shall terminate in a safe area at high level.

**4. 3** Earth all lines and equipment where there is the possibility of electro-static discharge.

**4. 4** Electrical equipment shall be certified to BS EN 60079 (36) or equivalent and selected, installed and maintained in accordance with that standard.

**4. 5** Electrical circuits shall be in accordance with BS EN 60079 (36).

**4. 6** Pipework shall be purged out of service with inert gas until the residual hydrogen concentration is below 1 % and purged into service with an inert gas until all residual oxygen is removed.

**4. 7** Each outlet point of the system shall terminate in a left hand thread.

**4. 8** Pipework shall have a separation distance of 50 mm from electrical systems.

**4. 9** Pipework should be segregated from other pipework carrying oxidising gases and sources of ignition to prevent combustion occurring.

**4. 10** Warning notices "Flammable Gas, No Smoking, No Sources of Ignition" and EX in accordance with DSEAR (6) shall be displayed. Where the notice uses a pictorial symbol, then this shall be in accordance with The Health and Safety (Safety Signs & Signals) Regulations (2).

**4. 11** Fire fighting equipment shall be readily available to deal with fires not involving the gas, but fire fighting should normally be done by the Fire & Rescue Service.

**4. 12** Hydrogen may spontaneously ignite in the event of a leak or in the event of a relief device opening. Hydrogen flames are almost invisible and produce no radiant heat. The approach to them must be made with caution.

**4. 13** Hydrogen is an extremely light gas which will readily collect at high level, therefore adequate ventilation in such places as the roof of a storage room is necessary to prevent accumulation of gas which could form a potentially explosive atmosphere.

**4. 14** Separation distances for hydrogen installations shall take into consideration vertical distances.

**LIQUEFIED PETROLEUM GAS (LPG)**

## 1 GENERAL DATA

| | Propane | Butane |
|---|---|---|
| Chemical symbol | $C_3H_8$ | $C_4H_{10}$ |
| Flammable / non-flammable | Flammable | Flammable |
| Lighter / heavier than air | Heavier | Heavier |
| Colour | Colourless | Colourless |
| Odour * | Odourless * | Odourless * |
| Taste | Tasteless | Tasteless |
| Toxicity | Non-toxic | Non-toxic |
| Corrosive | Non-corrosive | Non-corrosive |

* Commercial grades of LPG have a strong smelling additive to assist detection by smell.

## 2 RECOMMENDED MATERIALS

| | |
|---|---|
| Pipe | Copper / Copper alloy - Not to be used with LPG containing acetylene compounds if copper content is above 60 %.<br>Steel.<br>Plastic – As allowed by UKLPG Codes. |
| Jointing | PTFE.<br>Compressed fibre. |
| Valves and other components | All commonly-used materials are suitable. |

## 3 SPECIAL CONDITIONS

**3. 1** LPG is much heavier than air and will collect in low-lying positions where it will remain for long periods before it is dissipated. Storage areas and vent positions should be selected with this point in mind.

**3. 2** Cylinders must be kept vertical. Although LPG is stored as a liquid, this Code applies only to pipework conveying gas.

**3. 3** Compression fittings may be used in well-ventilated areas.

## 4 SAFETY

**4. 1** Butane is mildly narcotic. Additionally LPG-enriched atmospheres can cause asphyxiation through the depletion of oxygen.

**4. 2** Vent lines shall terminate in a safe area where gas will not accumulate to form a hazard.

**4. 3** Earth all lines and equipment where there is the possibility of electro-static discharge.

**4. 4** Electrical equipment shall be certified to BS EN 60079 (36) or equivalent and selected, installed and maintained in accordance with that standard.

**4. 5** Electrical circuits shall be intrinsically safe, explosion-proof or part of a safety barrier circuit in accordance with BS EN 60079 (36).

**4. 6** Pipework shall be purged out of service with inert gas where hot work is to be carried out and purged into service and leak tested with the service gas or an inert gas.

**4. 7** Each outlet point of the system shall terminate in a left hand thread.

**4. 8** Pipework shall have a separation distance of 50 mm from electrical systems.

**4. 9** Consideration shall be given to segregating LPG pipework from cylinders and other pipework carrying oxidising gases where leakage may occur.

**4. 10** Warning notices indicating "Flammable Gas, No Smoking, No Sources of Ignition" and EX in accordance with DSEAR (6) shall be displayed. Where the notice uses a pictorial symbol, then this shall be in accordance with The Health and Safety (Safety Signs & Signals) Regulations (2).

**4. 11** Fire fighting equipment shall be readily available to deal with fires not involving the gas, but fire fighting should normally be done by the Fire & Rescue Service.

**4. 12** The UKLPG Association CP 1 (58) and CP 7 (58) relating to the keeping of LPG should be consulted. DSEAR (6) applies.

**METHANE**

## 1 GENERAL DATA

Methane is the first of the paraffin series of hydrocarbons and is the main constituent of natural gas.

| | |
|---|---|
| Chemical symbol | $CH_4$ |
| Flammable / non-flammable | Flammable |
| Lighter / heavier than air | Lighter |
| Colour | Colourless |
| Odour | Odourless |
| Taste | Tasteless |
| Toxicity | Non-toxic (see Clause 3. 1) |
| Corrosive | Non-corrosive |

## 2 RECOMMENDED MATERIALS

| | |
|---|---|
| Pipe | Copper / Copper alloy - Not to be used with methane containing acetylene compounds if copper content is above 60 %.<br>Steel. |
| Jointing | All commonly-used materials are suitable.<br>Except soft solder |
| Valves and other components | All commonly-used materials are suitable. |

## 3 SAFETY

**3.1** Although methane is non-toxic, methane-enriched atmospheres can cause asphyxiation through the depletion of oxygen.

**3.2** Vent lines shall terminate in a safe area where gas will not accumulate to form a hazard.

**3.3** Earth all lines and equipment where there is the possibility of electro-static discharge.

**3.4** Electrical equipment shall be certified to BS EN 60079 (36) or equivalent and selected, installed and maintained to that standard.

**3.5** Electrical circuits should be intrinsically safe, explosion-proof or part of a safety barrier circuit in accordance with BS EN 60079 (36).

**3.6** Pipework shall be purged out of service with inert gas until the residual is below 1 % and purged into service using an inert gas until all traces of oxygen are removed.

**3.7** Each outlet point of the system shall terminate in a left hand thread.

**3.8** Pipework shall have a separation distance of 50 mm from electrical systems.

**3.9** Pipework should be segregated from other pipework carrying oxidising gases and ignition sources to prevent combustion occurring.

**3.10** Warning notices indicating "Flammable Gas, No Smoking, No Sources of Ignition" and EX in accordance with DSEAR (6) shall be displayed. Where the notice uses a pictorial symbol, then this shall be in accordance with The Health and Safety (Safety Signs & Signals) Regulations (2).

**3.11** Ventilation shall be provided at high levels to prevent accumulation of gas which could form a potentially explosive atmosphere.

**3.12** Separation distances for methane installations shall take into consideration vertical distances.

**3.13** Fire fighting equipment shall be readily available to deal with fires not involving the gas, but fire fighting should normally be done by the Fire & Rescue Service.

**CARBON DIOXIDE**

## 1 GENERAL DATA

| | |
|---|---|
| Chemical symbol | $CO_2$ |
| Flammable / non-flammable | Non-flammable |
| Lighter / heavier than air | Much heavier (see Clause 4. 3) |
| Colour | Colourless |
| Odour | Slightly pungent odour at high concentrations. |
| Taste | Tasteless |
| Toxicity | Slightly toxic (see Clause 4. 1). |
| Corrosive | Non-corrosive (in absence of moisture). |

## 2 RECOMMENDED MATERIALS

| | |
|---|---|
| Pipe | Copper / Copper alloy.<br>Steel.<br>Plastic - within the limitations set out in Appendix 10. |
| Jointing | Glass filled PTFE.<br>Compressed fibre. |
| Valves and other components | Most commonly-used materials are suitable.<br>(see Clauses 4. 4 and 4. 5). |

## 3 SPECIAL CONDITIONS

Nil

## 4 SAFETY

**4.1** Although carbon dioxide is usually considered to be non-toxic, it does have a long-term (8 hours) workplace exposure limit of 5000 ppm and a short term (15 minutes) workplace exposure limit of 15,000 ppm. Respiration is affected, breathing becomes laboured and mild narcotic effects may be experienced. At high concentrations paralysis of the respiratory system occurs and asphyxiation through depletion of oxygen can result. Refer to HSE publication EH 40 (11).

**4.2** Warning notices indicating inert gas storage shall be displayed. Carbon dioxide is usually considered as an inert gas but under certain conditions of temperature and pressure it will react with certain other substances which are themselves highly reactive. Further guidance should be obtained from the gas supplier.

**4.3** Carbon dioxide is considerably heavier than air and will remain in low lying places for long periods, this fact will influence the gas storage location and ventilation requirements which should be adequate at low level to prevent enrichment occurring.

**4.4** Piping, valves and fittings for use with liquid carbon dioxide may require low temperature properties and impact tested materials. A relief valve shall be interposed between any two stop valves where liquid carbon dioxide may be trapped. A bursting disc shall not be used.

**4.5** High tensile brass is not a recommended material.

**4.6** Discharge of liquid carbon dioxide can generate static electricity and it should be avoided in or near flammable gas mixtures.

**MIXED GASES**

## 1 GENERAL DATA

Contact the mixture supplier for full details of the physical properties, potential hazards, safety precautions and operating procedures for the particular gas mixture to be used.

When these facts are known, identify what materials can safely be specified for piping, hoses and other equipment used in the supply and distribution system and design the system on this basis, taking into account also the operating and design pressure requirements.

Establish safe procedures for installation, operation and maintenance of the system and agree emergency procedures to cover any potentially hazardous incidents which may occur.

Consideration should be given to withdrawal rates from the system - this will affect sizing of the manifold and piping and, in the case of liquefied gases in cylinders, the number of cylinders required. The possibility of freezing up of pressure regulators should also be considered (e.g. methane / natural gas mixtures).

Identify if, under certain conditions, condensable products can be obtained in the system from the mixture, and establish any precautions or modifications which may be required, e.g. drainage points, trace heating.

For flammable mixtures, ensure that cylinders and manifolds, equipment and pipework are adequately and continuously earthed.

A relief valve shall be interposed between any two stop valves where liquid may be trapped.

Consideration shall be given to the withdrawal to ensure the mixed gas is delivered at the usage point in the correct ratio.

Ventilation shall be provided at high and low levels as necessary to prevent enrichment of the normal atmosphere.

**PLASTIC PIPES**

## 1 GENERAL DATA

Plastic pipe may be used in inert gas service providing that the following criteria are met:

a) There shall be a minimum ratio between the burst and the safe working pressure of 4:1.

b) The design temperature shall be within the range –20 °C to +50 °C.

NOTES:

1) Most plastics become embrittled at low temperatures and should not therefore be used where temperatures below –20 °C are likely to be encountered.

2) The maximum working pressures of plastics reduce as the operating temperature increases, therefore care must be taken in terms of the operating environment in which materials of this nature are being considered for use, in order to ensure that the working pressure does not exceed the design pressure at the operating temperature.

c) Where plastic pipe is proposed to be used, due attention shall be paid to the coefficient of expansion of the material when designing such systems in order to make allowance for this factor.

d) Most plastics degrade in the presence of UV light and this should also be taken into consideration at the design stage, bearing in mind the operating pressures, temperatures and environment in which the system is to operate, in order to ensure that a suitable design life is specified.

e) Plastic pipe is potentially more easily damaged than piping manufactured from steel or copper. Care must therefore be taken to ensure that this factor is also taken into account at the installation stage.

Where flexible plastic pipe is used, sufficient supports should be used to prevent the pipe from sagging between supports, supporting on cable trays rather than on standard support systems may be a preferable alternative.

## BCGA OPINION ON THE USE OF GAS CABINETS

A European standard, BS EN 14470, Part 2 (35), exists for gas cylinder storage cabinets, though BCGA was not involved in the creation of that standard.

BCGA advice generally is to recommend external (outdoor) storage of gas cylinders in well secured compounds or cages and piping into buildings where needed. But we acknowledge that internal storage is sometimes necessary where the above is not suitable / practicable or does not suit the gas product or process (see below). In that case our recommendation is a well signed dedicated store room.

The Fire & Rescue Service view is unambiguous. They do not like to encounter gas cylinders in cabinets at all, regardless of the nature of hazard of the gas, or its potential contribution to fire load (all gas cylinders, even those containing inert gases will ultimately rupture if exposed to fire). If the contents are a fuel gas or oxygen then the fire load will be significantly increased.

Firefighters want to be able to see and apply cooling water to cylinders <u>from a distance</u> in a fire, but they also want cylinders secured against theft, so external storage in locked cages is very much their preference.

Whether a cabinet has 30 or 90 minutes fire resistance makes little difference to Firefighters, since they won't likely know where they are on that timescale in a real fire scenario. But even with the higher fire rating it is questionable whether such cabinets would keep cylinders below the 60 °C temperature norm, which guides the maximum developed pressure most cylinders are designed for.

HOWEVER, we also recognise that in some specialised gas uses, storage in suitable extraction cabinets may have merit:

a) Where there is a personal safety or process quality consideration, e.g. toxic or ultra high purity gases are needed, for example in the electronics industry.

b) Where gases / mixtures require to be temperature controlled for process reasons.

In such cases cabinets should only be used for cylinders which are connected and in current use and not for storage of full inventory or ‘empty’ cylinders awaiting return, both of which should be held in secure external storage.

Where cylinders are held in cabinets, prominent and fire resistant signage should be visible on the outside of storage cabinets and on the buildings/rooms which house them and consideration should be given to notifying the local fire service of the existence and whereabouts of gas cylinders in buildings.

The placing of cylinders into cabinets and their removal also presents manual handling risks, for which suitable training should be given. BCGA GN 3 (53) refers.

British Compressed Gases Association
www.bcga.co.uk