CODE OF PRACTICE 18

THE SAFE STORAGE, HANDLING AND USE OF SPECIAL GASES

Revision 3: 2014

British Compressed Gases Association

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BRITISH COMPRESSED GASES ASSOCIATION
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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 5. This document replaces BCGA CP 18, Revision 2, 2005. It was approved for publication at BCGA Technical Committee 148. This document was first published on 01/05/2014. For comments on this document contact the Association via the website www.bcga.co.uk.

CONTENTS

Appendices:

* Throughout this publication the numbers in brackets refer to references in Section 14. Documents referenced are the edition current at the time of publication, unless otherwise stated.

TERMINOLOGY AND DEFINITIONS

Fire-resisting	A fire-resistant construction is one that has a fire-resistance of at least 30 minutes when tested from either side in accordance with BS 476 (32), *Fire tests on building materials and structures*.
Firewall	A firewall shall be imperforate and of at least 30 minutes fire-resisting construction. Such walls are usually solid masonry or concrete, but barriers constructed of other materials, e.g. earth banking, may be equally effective.
Gas	To cover single component gases, compressed gas mixtures, liquefied gases and liquids.
May	Indicates an option available to the user of this Code of Practice.
Segregated storage	Grouping together of containers of a given gas or category of gases or segregating full from nominally empty containers.
Separated storage	The separation of containers of a given category of gases from a particular feature (e.g. a building or other containers) by a certain distance (see Table 4) - or by a physical barrier (e.g. a firewall).
Shall	Indicates a mandatory requirement for compliance with this Code of Practice.
Should	Indicates a preferred requirement but is not mandatory for compliance with this Code of Practice.

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1. INTRODUCTION

This Code of Practice was originally prepared at the request of the "Micro-Electronics Semiconductor Manufacturer's Joint Working Group" by a group of experts including representatives of the British Compressed Gases Association (BCGA), the Federation of the Electronics Industry and the Health and Safety Executive (HSE) with consultation with Trade Unions.

NOTE: The Federation of the Electronics Industry was dissolved in 2002.

At the request of the Joint Working Group this Code of Practice was published as a BCGA document.

Increasing quantities of special gases are produced, distributed and stored each year and although many companies have developed their own procedures and engineering standards, it is considered that this Code of Practice will be of benefit to the micro-electronics semiconductor manufacturing industry, micro-electronics semi-conductor research laboratories and other industries using special gases. The standards and guidelines in this Code of Practice reflect the best advice available at time of issue. It is not intended to be fully comprehensive and further guidance may be sought from BCGA or HSE.

2. SCOPE

This Code of Practice gives technical and safety guidelines and principles for the safe storage and handling of special gases in transportable containers up to the point where product is provided at the required pressure and flow at the junction with the user process. Guidelines on disposal are also given. The Code will assist companies to formulate their own design and operation policies and practices for the storage, handling and use of special gases. The safe operation of processes is not included, although many of the principles given in this Code will apply.

Bulk supply installations, gases in the cryogenic state, gas manufacturing, container filling and container distribution are not covered by this Code.

3. KEY REQUIREMENTS

Under the Health and Safety at Work etc. Act (1) and as detailed in legislation, such as the Control of Substances Hazardous to Health (COSHH) (11) Regulations and the Management of Health and Safety at Work Regulations (8), employers are required to carry out assessments in order to minimise the risks to the health and safety of their employees. Some of the products covered within this document will also fall within the scope of the Control of Major Accident Hazards Regulations (COMAH) (7). Where employers are involved in using and storing such products the requirements of this legislation shall be complied with.

To assist in this, employers of personnel using special gases shall:

(i) Be aware of and meet their duties under the Health and Safety at Work etc., Act (1), and its relevant statutory provisions;

(ii) Be aware of and meet their duties under the Registration, Evaluation, Authorisation and restriction of CHemicals (REACH) Regulations (23), and its relevant statutory provisions.

(iii) Follow the requirements of the COSHH (11) Regulations;

(iv) Be aware of and meet their duties under the Dangerous Substances (Notification and Marking of Sites) Regulations (NAMOS) (3). This regulation requires notification to the authorities where a total quantity of hazardous products of 25 tonnes or more are stored, specific exemptions apply.

(v) Ensure that information is provided on the potentially hazardous properties of all gases used and take the necessary precautions to deal with them safely using the information and advice given by the supplier's Safety Data Sheets;

(vi) Ensure that proper equipment and facilities are provided in order to transport and store containers safely;

(vii) Ensure that proper equipment and facilities are provided to transfer gas safely from the gas container to the point of use at the required pressure and flow. This will mean ensuring that the requirements of the Pressure Systems Safety Regulations (PSSR) (9) are fully complied with;

(viii) Provide a safe means of disposal for waste gases such that health and the environment are not damaged;

(ix) Provide all the necessary personal protective equipment for the safe handling of containers including their connection and disconnection to and from the gas system;

(x) Maintain all gas supply systems, and gas disposal systems in a safe state;

(xi) Ensure that all necessary equipment, procedures and training are provided to enable any emergency situation to be dealt with promptly, safely and efficiently;

(xii) Ensure that all personnel are properly trained in any activity associated with the handling of containers and the supply and disposal of these gases.

(xiii) Premises used for the handling, use and storage of special gases shall be adequately protected by security systems.

4. POTENTIAL HAZARDS OF COMPRESSED GAS CONTAINERS

This section summarises the principal hazards associated with gas containers. Subsequent sections deal with the practical requirements for overcoming these hazards.

4.1 Mass of containers

Most accidents with containers of compressed gases occur in their handling due to their mass, shape and size. When moving such containers or working with them they can present risk of damage to hands, fingers and feet. Refer to Section 7 for advice on manual handling.

4.2 Potential uncontrolled release of gas

Uncontrolled release of any gas due to inadvertent opening or shearing of the container valve can present hazards to people and equipment. This hazard could be from the specific properties of the gas, and/or from the release of a gas under pressure which could turn the container into a projectile.

4.3 Temperature effects

The amount of gas in a container, as supplied, is carefully controlled to ensure that unacceptable pressures cannot develop under the highest ambient temperature likely to be encountered in the climatic area of use, refer to BCGA Code of Practice (CP) 35 (58), *Filling ratios and developed pressures for liquefied and compressed gases*. Gas containers shall not be deliberately heated above ambient temperature without prior consultation with the supplier.

NOTE: For the regulations on the acceptable developed pressures in the United Kingdom reference should be made to the European Agreement on the Carriage of Dangerous Goods by Road (ADR) (18), which is implemented in the United Kingdom by the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (15).

Containers exposed to high levels of radiant heat, e.g. from a local heat source such as a nearby fire or boiler, may burst due to over-pressurisation. Gas containers are to be stored in accordance with Section 6. Gas containers in use are to be sited in accordance with Section 8.

Where containers are exposed to high levels of heat, the contents of the gas container will also be subject to high levels of heat which may cause ignition.

Aluminium containers shall not be heated above ambient temperature because they may exhibit permanent softening of the aluminium alloy and could present a possible future hazard. The majority of aluminium containers within the scope of this document will have been treated with heat sensitive coatings or high temperature indication which will indicate any excessive exposure to heat. Where known cases of inadvertent heating of aluminium containers have occurred, the gas supplier shall be advised, so that suitable safety measures can be applied.

Steel containers, whilst not as susceptible as aluminium, can still be affected by excessive heat. Composite containers can be badly affected by fire though melting of the resin and burning of the fibres.

In all cases where a container has been subjected to excessive heat, or has been directly involved in a fire, the container is to be quarantined, and the gas supplier requested to collect the container.

Fire damaged gas containers. Do not use any fire-damaged containers. Quarantine any fire-damaged containers in a safe place. Mark, or label, fire-damaged containers to clearly show that they have been in a fire. Inform your gas supplier whenever a containers is involved in a fire. After the fire is out, and the area has been declared safe by the Fire and Rescue Service, the gas supplier will arrange collection of fire damaged containers at a convenient date. Refer to BCGA Leaflet 6 (67), *Cylinders in fire*.

NOTE: Contact numbers for the gas supplier are available on the product Safety Data Sheet.

Some containers may suffer embrittlement if subjected to temperatures below -20 ^{o}C. Gas containers shall not be deliberately cooled to these temperatures without prior consultation with the supplier.

4.4 Container valve outlets

Valve outlet connections are manufactured to approved standards. Examples are:

- BS 341 (31), *Transportable gas container valves*;
- ISO 5145 (34), *Cylinder valve outlets for gases and gas mixtures. Selection and dimensioning;*
- German DIN 477 (68), *Gas cylinder valves for cylinder test pressures up to 300 bar*;
- USA CGA V-1 (70), *Standard for compressed gas cylinder outlet and inlet connections*.

It is possible that different container valve outlets for the same gas on the same user site may be of differing standards. Extreme care shall be taken to ensure that only the correct connections are used. If any doubt exists, check with the gas supplier.

Additional protection against high discharge rates of pyrophoric and toxic gases (e.g. flow limiting orifices fitted to the valve outlet) should be fitted where maximum process demand allows.

Where gas containers are supplied with valve outlet sealing plugs or cap-nuts and valve protection caps acting as a secondary seal it is essential that these are refitted after use. Inadvertent opening of the valve or slight leakage across the valve may be hazardous if these secondary seals are not correctly fitted. This hazard also potentially exists when containers are nominally empty.

4.5 Identification of container contents

It is potentially hazardous to use a container whose content is not positively identified. The cylinder label shall always be used as the primary means of identifying the

contents of a gas container. Identification is normally by the UN Number and the Proper Shipping Name. This may also be stencilled on the container. Container colour is a secondary method of identifying the contents but shall not be relied upon for positive content identification, as many different colour codes exist.

Refer to Section 5 for further information on the hazards of a gas and their classification. Refer to BCGA Technical Information Sheet (TIS) 6 (63), *Cylinder identification. Colour coding and labelling requirements*, for information on the colour coding and labelling of gas cylinders.

4.6 Misuse of containers

It is potentially hazardous to use full or nominally empty containers other than for their designed purpose (e.g. misuse as rollers, roadways, door-stops, etc.). Such misuse may result in damage to the container or its valve, possibly causing leakage (of a hazardous product), or creating a hazard during subsequent refilling of the container.

Users shall not refill gas containers without the authorisation of the owner of the container.

4.7 General

Any container for which the contents cannot be accurately identified, or which is known to have been misused or subjected to a potential hazard, shall be set aside and the gas supplier notified so that appropriate safety measures can be taken.

5. POTENTIALLY HAZARDOUS PROPERTIES OF GAS

This section summarises the principal hazardous properties of gases. Subsequent sections deal with the practical requirements for overcoming these hazards.

There are potentially hazardous properties for many of the pure gases. Gas mixtures are not covered in detail in this section, however, the same range of potential hazards may exist for mixtures as with pure gases, the hazards being dependent on the mixture components and their concentrations. Full details of the hazardous properties of each gas will be given in the Safety Data Sheet and basic information displayed on the product identification label. Wherever technically possible the use of less hazardous gases should be considered by users.

It is a legal requirement that the gas supplier provides a Safety Data Sheet to the user whenever a product is supplied for the first time, in accordance with the Chemicals (Hazard Information and Packaging for Supply) CHIP (14) Regulations. The exact requirements for Safety Data Sheets are included in the REACH Regulations (23). Safety Data Sheets can be obtained for all gases and are to be available for the user of the gas. The information within the Safety Data Sheet shall be have been considered before design work or handling of any gas container commences.

NOTE: The CHIP (14) Regulations brings national legislation into line with the transitional arrangements set out in European Regulation (EC) No 1272/2008 (22) on the Classification, Labelling and Packaging of Substances and Mixtures (CLP). The CLP (22) Regulation entered into force across all EU member states, including the UK, in January 2009. The CLP (22) Regulation has applied to substances that are placed on the market since 1 December

2010. It is not mandatory to use the CLP (22) classification system to classify chemical mixtures (preparations) until 1 June 2015. The CHIP (14) Regulations will be repealed from 1 June 2015, from when suppliers must comply with the CLP (22) Regulation.

The potential hazardous properties of many of the pure gases can be found in the following references:

- European Chemicals Agency (ECHA)
- REACH (23) Registration Dossiers
- ADR (18) Packing Instruction P200
- BS ISO 10298 (39), *Determination of toxicity of a gas or gas mixture*

5.1 Flammability

For the purpose of this code, a gas is defined as being flammable if it can form mixtures with air that will freely propagate a flame. The flammable range is normally defined as the range of concentrations of the gas in air which will propagate a flame. Mixtures of flammable gas(es) with air or other oxidants within the flammable range have the potential to explode. The severity of an explosion caused by the ignition of a flammable gas / air or other oxidant mixture depends on several factors including the quantity and extent of enclosure or confinement of the gas mixture.

There is an upper and a lower limit defined for each gas or homogeneous gas mixture. The lower flammability limit can be found in BS EN ISO 10156 (38), *Gases and gas mixtures - Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets*. Refer to the gas suppliers Safety Data Sheet for both the lower and upper flammability limit. The flammability limits may vary considerably with pressure and the nature and content of other gases in the mixture.

5.1.1 Pyrophoric gases

Pyrophoric gases may spontaneously ignite and burn in air (or other oxidants). Under some conditions, spontaneous ignition may not occur, resulting in the formation of a mixture of the pyrophoric gas with air or other oxidant gas, which may be unstable and potentially explosive.

Examples include arsine, phosphine and silane. Further information on these gases can be found in the European Industrial Gases Association (EIGA) Document 163 (54), *Code of practice, arsine,* EIGA Document 162 (53), *Code of practice, phosphine*, and EIGA Document 160 (52), *Code of practice, silane.*

5.2 Oxidising potential

Oxidising gases will react with flammable gases and other combustible materials in a manner similar to oxygen, i.e. they will support combustion.

Some oxidising gases will support combustion more vigorously than air or oxygen and may react spontaneously with some flammable gases and other materials.

Some organic materials, e.g. hydrocarbon based oils, greases, plastics, etc. may react explosively with oxygen and more powerful oxidants, e.g. fluorine. The severity of such an explosion will depend on pressure, temperature, reactivity and concentration of the reactive components and temperature. Metal – oxygen, or metal fires in the presence of other oxidants, may be initiated by the presence of hydrocarbon oil, grease, other organic contaminant or particulate matter, refer to Section 9.11. Oxidising potential can be assessed by the use of the data in BS EN ISO 10156 (38).

HSE has determined that for normal working a level of oxygen concentration between 19.5 % and 23.5 % is necessary. Oxygen levels above 23.5 % create an oxygen enriched atmosphere which greatly increases the flammability of material.

5.3 Toxicity

A toxic substance is one which, in low quantities, can cause death or acute or chronic damage to health when inhaled, swallowed or absorbed by the skin. In the case of gases, the route of bodily ingress is usually by inhalation.

Further information is available in the EIGA Document 130 (49), *Principles for the safe handling and distribution of highly toxic gases and mixtures*.

5.3.1 LC50 / 1 hour

The LC50 / 1 hr is the concentration of a toxic gas in air which is expected to result in the death of 50 % of an animal population (normally rats) when exposed for a period of 1 hour. These values are provided in BS ISO 10298 (39) which is based on a wide range of data from published papers.

5.3.2 Workplace exposure limits

HSE Guidance Note EH 40 (24), *Workplace exposure limits*, gives details of the workplace exposure limits which should be used for purposes of determining the adequacy of control of exposure by inhalation of substances hazardous to health. Reference to the current HSE Guidance Note, which is regularly reviewed and revised as necessary, should be made.

5.3.3 Derived no-effect level

The (REACH) (23) regulations define the derived no-effect level (DNEL) as the level of exposure to a substance above which humans should not be exposed. Refer to the REACH (23) registration dossiers on the European Chemicals Agency (ECHA) website, as well as the suppliers Safety Data Sheet for further information.

NOTE: ECHA website link: http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances

5.4 Corrosivity

A corrosive gas is one which, on direct contact, may harm human tissue.

Many corrosive gases may also react with certain materials of construction causing material damage and possible failure. Corrosive gases may only react with a material in the presence of water or moisture from the atmosphere or other sources. Products of

corrosion can include other gases, e.g. hydrogen, giving rise to possible pressure and flammability hazards.

To prevent any potential impact from water, gas suppliers carry out additional procedures to ensure cylinders are dry before filling and that filling systems are designed to prevent the ingress of air and moisture during filling. Further information on the extra management controls in place for the supply and storage of cylinders in corrosive gas service can be found in BCGA TIS 33 (66), *Good industry practice for the supply of cylinders containing corrosive gases*, for gas suppliers and for users' in BCGA TIS 16 (64), *The storage of gas cylinders containing corrosive gas at users' premises.*

5.5 Asphyxiant

Asphyxiation hazards exist with any gas or gas mixture which does not contain sufficient oxygen to support life. Such gases or gas mixtures will displace the available oxygen in the atmosphere to a level which is unsafe or may not support life.

For normal working a level of oxygen concentration at or above 19.5 % is necessary. Atmospheres containing less than 18 % oxygen are potentially dangerous and entry into such areas must be prohibited unless appropriate safety controls are adopted.

It should be noted that all gases except oxygen, air and gas mixtures manufactured specifically for breathing can be asphyxiant at atmospheric pressure. Many such gases may well present other hazards such as fire or toxicity risks. The concentrations at which these other hazards can arise are likely to be well below those at which asphyxiation occurs.

BCGA Guidance Note (GN) 11 (61), *Reduced oxygen atmospheres. The management of risk associated with reduced oxygen atmospheres resulting from the use of gases in the workplace*, provides further information on the management of risk associated with reduced oxygen atmospheres resulting from the use of gases in the workplace.

5.6 Carcinogenicity, mutagenicity and reprotoxicity

There are a few gases which may exhibit one or more of the hazards of carcinogenicity, mutagenicity and reprotoxicity (CMR). Where this is the case, information shall be given in the supplier's Safety Data Sheet and indicated on the gas container contents label.

Under REACH (23) it is possible for products to be added to the Candidate List for potential future Authorisation. Some CMR's may become designated "Substances of Very High Concern" (SVHC's). Authorisation is the process under REACH (23) whereby the risks from SVHC's are properly controlled and progressively replaced by alternative safer substances.

Any substance classified as a CMR, PBT (persistent, bioaccumulative and toxic) or vPvB (very persistent and very bioaccumulative) or any substance which may cause an equivalent level of concern (e.g. respiratory sensitisers, endocrine disruptors) may be recommended for inclusion on the Candidate List for Authorisation.

Although it is not explicitly stated in the REACH (23) text, it is expected that companies who supply products / mixtures containing substances on the Candidate List above a concentration of 0.1% (weight by weight) will communicate the presence of such SVHC via their Safety Data Sheet. This is to enable producers and importers of articles (i.e. a finished product) to meet their obligations under REACH (23).

REACH (23), Article 7(2) states that producers and importers of articles have to notify to ECHA the substances listed on the Candidate list which are present in their articles, if both the following conditions are met: the substance is present in their relevant articles above a concentration of 0.1 % weight by weight and the substance is present in these relevant articles in quantities totalling over one tonne per year. However, a notification is not required if the producer or importer of an article can exclude the exposure of humans and the environment to the substance during normal or reasonably foreseeable conditions of use of the article, including its disposal or the substance has already been registered by a manufacturer or importer in the European Union for that use.

Furthermore, REACH (23) Annex II is more explicit in stating that substances subject to Authorisation (i.e. included in REACH (23) Annex XIV) should be declared in Section 15 of the Safety Data Sheet.

5.7 Pressure of a gas in its container

Gases are supplied in containers manufactured to approved standards, e.g. cylinders and drums.

The most significant hazards that can arise directly from the gas pressure in a container are:

(i) Exposure of the container to excessive heat, which could result in its rupture due to over pressurisation and / or heat weakening its material of construction;

(ii) Mechanical or corrosion damage to the container valve, or some other part of the container, which could result in a rapid escape of gas which may generate sufficient thrust to propel the gas container or other adjacent objects.

Containers should not be allowed to be exposed to chemicals which could affect their mechanical properties. This is particularly important with containers manufactured from composite materials.

5.8 Other hazards which may arise from the physical or chemical properties of a gas

It is beyond the scope of this code to cover all possible hazards. Details should be sought from suppliers' Safety Data Sheets and, in cases of doubt, by direct consultation with suppliers.

Examples of other gas properties that may be relevant include:

(i) Densities of gases including liquid phases where appropriate, e.g. for design of ventilation systems. Some gases are heavier than air, some are lighter. Heavier than air gases may accumulate in confined spaces at or below ground level, lighter than air gases may accumulate in roof spaces;

(ii) Relative Densities. The densities of gases are commonly quoted as having a relative density to air, where air is equal to 1. In addition, for liquefiable gases, the liquid phase density is given relative to water, where water is equal to1. Refer to the gas suppliers Safety Data Sheet.

(iii) Vapour Pressure. The pressure exerted by a vapour in equilibrium with a liquefiable gas e.g. ammonia, in a container. It is important to consider the relationship between vapour pressure / temperature for liquefiable gases, e.g. to avoid unwanted liquefaction of gases in, or over pressurisation of, gas handling systems. Refer to the gas suppliers Safety Data Sheet.

(iv) Polymerisation potential, e.g. certain gases may polymerise readily under some conditions, e.g. heat, contact with acid / alkaline radicals, etc. Such reactions may generate heat and pressure which may present a hazard if uncontrolled;

(v) The latent heat of vapourisation of liquefied gases - most liquefied gases are capable of causing cold burns when spilt on the skin or in the eyes.

(vi) Environmental hazards such as ozone depletion, aquatic toxicity, greenhouse effect. Such hazards will be identified by reference to the Safety Data Sheet and the product identification label as required by legislation.

5.9 Classification

All gases are classified based on their intrinsic properties. When in use they have to be classified against the CLP (22). When being transported they comply with the UN Recommendations on the Transport of Dangerous Goods, Model Regulations (16), which in the UK means compliance The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (15) which implements ADR (18) for road transportation. It is mandatory for all containers to have a product identification label displayed identifying the product and advising of any associated hazard or safety requirements.

In January 2009, the CLP (22) regulations were introduced in to the European Union to align previous European Union legislation on the classification, labelling and packaging of chemicals with the UN Globally Harmonised System of Classification and Labelling of Chemicals (GHS) (17). The CLP (22) Regulation amends and repeals European Directive 67/548/EEC (19) on the classification, packaging and labelling of dangerous substances.

The CLP (22) Regulation is being implemented in stages:

- All pure substances have had to have been classified, labelled and packaged in line with the CLP (22) regulations since the 1st December 2010.

- All mixtures will need to be classified, labelled and packaged according to the CLP (22) regulations by the 1st June 2015, but may be implemented earlier.

- The hazards of both pure substances and mixtures need to be notified to the European Chemicals Agency (ECHA) regardless of quantity.

NOTES:

1. There is a two year period of grace to allow cylinders, which have already been supplied, to be used with their existing classification.
2. Non-European Union imports may be supplied with classifications which are not in accordance with CLP (22).

5.9.1 Dangerous substances and dangerous preparations directives

Gas classifications (which summarise the key hazardous properties) are given, as listed in Annex 1 of the European Directive 67/548/EEC (19) on the classification, packaging and labelling of dangerous substances.

The classification symbols currently used are defined in the CHIP (14) Regulations and are as detailed in Table 1. These remain extant until 1st June 2015.

Symbol	Classification
O	Oxidant
F+	Extremely flammable
F	Highly flammable
T+	Very toxic
T	Toxic
Xn	Harmful
C	Corrosive
Xi	Irritant
Carc (1,2,3)	Carcinogenic
Mut (1,2,3)	Mutagenic
Repr (1,2,3)	Toxic for reproduction
N	Dangerous to the environment

Table 1: Classification symbols

A dash in the list indicates that the gas is treated, for classification purposes, as not exhibiting any of the above properties. There may, however, be other hazards such as pressure, asphyxiant risk, etc.

5.9.2 Classification, labelling and packaging of substances and mixtures

				
GHS 01	GHS 02	GHS 03	GHS 04	GHS 05
				
GHS 06	GHS 07	GHS 08	GHS 09	

Table 2: GHS Pictograms

The pictograms and Hazard statements which are to be used under the CLP (22) regulations are detailed in Tables 2 & 3. These are to be applied for pure substances and are applicable for mixtures from 1st June 2015. For further details please refer to EIGA Document 169 (55), *Classification and Labelling Guide*.

Pictogram	Hazard statement	Classification	Phrase
GHS 02	H220	Flam. Gas 1	Extremely flammable gas
No additional pictogram required	H221	Flam. Gas 2	Flammable gas
No additional pictogram required	H230	Chem. Unst. Gas A	May react explosively even in the absence of air
No additional pictogram required	H231	Chem. Unst. Gas B	May react explosively even in the absence of air at elevated pressure and/or temperature
GHS 03	H270	Ox. Gas 1	May cause or intensify fire; oxidiser
GHS 04	H280	Press. Gas (Liq.Gas)	Contains gas under pressure; may explode if heated
GHS 04	H280	Press. Gas (Comp.Gas)	Contains gas under pressure; may explode if heated
GHS 04	H280	Press. Gas (Diss.Gas)	Contains gas under pressure; may explode if heated
GHS 04	H281	Press. Gas (Refr.Liq.Gas)	Contains refrigerated gas; may cause cryogenic burns or injury
GHS 06	H310	Acute Tox. 1	Fatal in contact with skin
GHS 05	H314	Skin Corr. 1	Causes severe skin burns and eye damage
GHS 07	H315	Skin Irrit. 2	Causes skin irritation
GHS 05	H318	Eye Dam. 1	Causes serious eye damage
GHS 07	H319	Eye Irrit. 2	Causes serious eye irritation
GHS 06	H330	Acute Tox. 1	Fatal if inhaled
GHS 06	H330	Acute Tox. 2	Fatal if inhaled
GHS 06	H331	Acute Tox. 3	Toxic if inhaled
GHS 07	H332	Acute Tox. 4	Harmful if inhaled
GHS 07	H335	STOT SE 3	May cause respiratory irritation
GHS 07	H336	STOT SE 3	May cause drowsiness or dizziness
GHS08	H340	Muta. 1	May cause genetic defects (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)
GHS08	H341	Muta. 2	Suspected of causing genetic defects (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)
GHS08	H350	Carc. 1	May cause cancer (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)

GHS08	H351	Carc. 2	Suspected of causing cancer (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)
GHS08	H360	Repr. 1	May damage fertility or the unborn child (state specific effect if known)(state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)
GHS08	H361d	Repr. 2	Suspected of damaging fertility or the unborn child (state specific effect if known) (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)
GHS08	H370	STOT SE 1	Causes damage to organs (or state all organs affected, if known) (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)
GHS08	H371	STOT SE 2	May cause damage to organs (or state all organs affected, if known) (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)
GHS08	H372	STOT RE 1	Causes damage to organs (state all organs affected, if known) through prolonged or repeated exposure (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)
GHS08	H373	STOT RE 2	May cause damage to organs (state all organs affected, if known) through prolonged or repeated exposure (state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard)
GHS09	H400	Aquatic Acute 1	Very toxic to aquatic life
GHS09	H410	Aquatic Chronic 1	Very toxic to aquatic life with long lasting effects
GHS 09	H411	Aquatic Chronic 2	Toxic to aquatic life with long lasting effects
No additional pictogram required	H412	Aquatic Chronic 3	Harmful to aquatic life with long lasting effects

Table 3: Commonly used CLP classifications

6. GAS CONTAINER STORAGE AREA

All gas containers are to be stored in accordance with BCGA GN 2 (59), *Guidance for the storage of gas cylinders in the workplace*. All storage areas shall be located with due regard to the minimum recommended separation distances specified in Table 4.

6.1 Key principles

Additional principles for the storage of special gases are:

(i) That they are contained in a secure store (but with clear access). Some special gases require a higher level of security. Only personnel authorised to handle/use special gases are to be allowed access to them. Access to keys is to be controlled. A key log is to be maintained. Keys are to be made available to the emergency services in the event of an incident.

(ii) Provided with clearly marked areas for each category of gas;

(iii) The location of special gases is to be clearly designated and shown on the site plan. This site plan is to be available to the emergency services in the event of an incident. The emergency services are to made aware of the additional hazards which may be encountered with special gases;

(iv) Special gases being prepared for distribution, or during carriage, are to comply with the security provisions of ADR (18), Chapter 1.10. All persons engaged in the carriage of dangerous goods have to consider the security requirements of ADR (18), commensurate with their responsibilities. High consequence dangerous goods require additional security arrangements.

(v) The gas supplier may agree with the customer safe and appropriate practice for the management of certain special gases, this may include audits of the customer's storage site. All personnel who are required to handle / use special gases are to have received appropriate training, this is to include the general properties of gases as well as the specific physical and chemical properties of the gases they are handling. Refer to Section 13.3.

(vi) All personnel who are required to handle / use special gases are to be authorised and a list of those personnel is to be maintained.

(vii) The store has to be appropriately marked and labelled to indicate the special nature of its contents. A list of personnel who are authorised to access the store is to be displayed.

(viii) Inventories of gases shall be managed so that they are kept to a practicable minimum.

(ix) Consideration is to be given to the provision and location of fire fighting equipment. Special gases may require additional precautions to be applied when fighting a fire. This is to be considered as part of the fire risk assessment carried out in accordance with the Regulatory Reform (Fire Safety) Order (13). Refer to Section 13.1.

(x) All personnel handling special gases are to be provided with appropriate Personal Protective Equipment (PPE). The presence of special gases may require additional PPE to be provided. Refer to Section 13.2.

(xi) If required, an appropriate gas detection system is to be provided and installed. Any gas detection system shall be fitted with audible and visible alarms. The alarm system is to be set to operate at an appropriate level e.g. in accordance with the Workplace Exposure Limit, refer to HSE Guidance Note EH 40 (24). All gas detection systems and alarms shall be maintained in accordance with the manufacturers requirements and tested at regular intervals. Refer to Section 13.7.

Typical type of exposure	**Features to be separated**	**Minimum separation distance** (in metres)
Smoking, naked flames	Storage area	3
Bulk storage of flammable gases and liquids	Storage area	3
Unprotected electrical equipment	Flammable gases	3
Site boundaries Air compressors and ventilator intakes Roadways (other than those required for access) Bulk storage of cryogenic liquids Building openings	Toxic and flammable gases	3
Site boundaries Air compressors and ventilator intakes Roadways (other than those required for access) Bulk storage of cryogenic liquids Building openings	Other gases	3
Pyrophoric gases in store	Other gas containers	2 (Refer to Section 8.5)
Pyrophoric gases connected for use	Other gas containers	2 (Refer to Section 8.4)
NOTE: These distances are recommendations only. The risk assessment may suggest other distances.		

Table 4: Minimum recommended separation distances

6.2 External storage location

The first principle for the location of any store is for it to be in the open air where there is good natural ventilation. The storage areas should be well defined. Stores containing special gases are to be located in an area where they are secure. Under specific circumstances containers may be stored internally, refer to Section 6.5.

The store shall be located with due regard to the minimum recommended separation distances specified in Table 4. The special properties of some gases may require these to be extended.

The store shall be located in an area away from sources of fire and/or ignition.

There shall be good access and egress for delivery vehicles.

6.3 Store design and construction

Gas containers should be stored at ground level.

The store should be covered by a roof to protect containers from the weather and to provide some protection against corrosion. The roof should be designed with vents so that gas cannot accumulate in the roof-space.

The storage area shall be constructed so as to allow a high standard of natural ventilation. Therefore as well as providing protection from the weather the store shall be constructed in such as way as to provide no opportunity for the build up of gases in an enclosed volume. The store shall be arranged so that gas leaks cannot collect in confined spaces, e.g. drains, pits, basement entrances, etc.

The design of the store is to take into consideration the density of the gases to be stored. Low-level ventilation is particularly important since many gases are heavier than air, but high level ventilation may also be required. The storage area shall have at least two sides that are sufficiently open so as to provide a high degree of natural ventilation. Open wire mesh of industrial quality or steel louvres are suitable materials for these free venting sides. Where practicable the two free venting sides should be opposite rather than adjacent.

The types of gases being stored may require an assessment of the number of air changes per hour that occur. Natural ventilation may be acceptable, but in some cases, forced ventilation systems may be required. Any forced ventilation systems are to be synchronised with the gas detection system.

Where reasonably practicable all parts of the storage area shall be constructed of non-combustible materials.

The floor shall be flat and constructed of concrete or other non-combustible, non-porous material. It should be laid to a fall, to prevent the accumulation of water. The slope of the floor shall be such that any product spill is directed to a low risk area.

The store will be required to be secure. Special gases often have hazardous properties, requiring that access to them is restricted to authorised personnel. Additionally, some gases need to be secured because they are attractive to thieves, for example, for drug

misuse or for the purposes of terrorism. The design of the store is to take account of the level of security necessary to protect the type of gases being stored.

Storage areas shall be located away from areas of fire risk. Fire extinguishing equipment should be readily available in all working areas. A water spray system that will operate either automatically or can be operated manually should be considered. All fire equipment as required in the fire risk assessment carried out in compliance with The Regulatory Reform (Fire Safety) Order (13) shall be provided. Refer to Section 13.1.

NOTE: In the event of a fire a water spray will ensure that containers are cooled in order to minimise the risk of rupture and with some gases water spray may also help to minimise the spread of any escaping gas.

Where flammable or oxidising gas containers are stored, a risk assessment in accordance with the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) (12) shall be carried out. Only electrical equipment certified as suitable for use in a Zone 2 area (or better) and constructed to a recognised standard shall be installed. As a minimum all electrical installations shall conform to BS 7671 (37), *Requirements for electrical installations. IET wiring regulations*. All fixed electrical equipment in the hazardous zones shall have the appropriate ATEX rating, refer to BS EN 60079, Part 14 (43), *Explosive atmospheres. Electrical installations design, selection and erection*. This restriction shall be applied within storage areas and outside the storage areas to the minimum recommended separation distances specified in Table 4.

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

- European Directive 99/92/EC (21) (also known as 'ATEX 137' or the 'ATEX Workplace Directive') on minimum requirements for improving the health and safety protection of workers potentially at risk from explosive atmospheres.

- European Directive 94/9/EC (20) (also known as 'ATEX 95' or 'the ATEX Equipment Directive') on the approximation of the laws of Members States concerning equipment and protective systems intended for use in potentially explosive atmospheres.

In the UK the requirements of Directive 99/92/EC (21) were put into effect through DSEAR (12). The requirements of Directive 94/9/EC (20) were implemented by the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations (EPS) (5). Compliance with DSEAR (12) and the EPS Regulations (5) is sufficient to confirm compliance with Directive 99/92/EC (21) and Directive 94/9/EC (20) respectively. Further guidance is available in HSE L138 (29), *Dangerous substances and explosive atmospheres. DSEAR 2002. Approved Code of Practice and guidance*, and additional information is available in EIGA Document 134 (50), *Potentially explosive atmospheres EU Directive 1999/92/EC.*

Where applicable, electrical equipment, which is necessary for the installation shall be to BS EN 60529 (44), *Specification for degrees of protection provided by enclosures*, protection class IP54 or better. For more severe environmental conditions protection class IP55 (designed to protect against water jets) should be used.

Adequate means of escape shall be provided. Liaison with the local Fire Authority is necessary to determine the number of exits required and appropriate travel distances. Any gates should be outward opening and wide enough to provide for an easy access and exit of personnel. Consideration should be given to the provision of an additional emergency exit where the size of the fenced area or store necessitates this. Where installed, all emergency exits are to open in the direction of escape and are to be fitted with panic furniture of a type not requiring a key, card, or code to open. They are to provide an unobstructed means of escape and in operation are not to obstruct any other escape route. These exits are to be properly identified by signage, and maintained in a serviceable condition at all times. The main gate should have two wings, each at least 0.6 m wide. The emergency exit gate should have one wing, at least 0.8 m wide.

Where necessary, protection shall be provided to prevent damage from vehicles. This may be a low wall, bollards or a crash barrier.

6.4 Store management

The store shall be used exclusively for the storage of gas containers.

The store shall be clearly labelled with the type or classification of containers it contains. Appropriate safety signs, e.g. "NO SMOKING", shall be erected in accordance with the Health and Safety (Safety Signs and Signals) Regulations (5). A sign shall be displayed detailing any specific action to be taken in the event of an incident/emergency and showing whom to contact in the event of an incident/emergency, with all appropriate contact details. This is to include the contact details for the gas supplier and the gas supplier's 24-hour emergency contact telephone number. The location of any access keys, as well as the contact details for the authorised key holder shall be displayed.

Sources of ignition shall neither be permitted within the storage area nor within the minimum recommended separation distances specified in Table 4. Accumulation of combustible materials shall not be permitted within or close to the storage area.

Where flammable or oxidising gas containers are stored a risk assessment shall be carried out to assess the suitability of portable electrical, electronic devices and other equipment that may be required for use. As required, appropriate controls are to be applied e.g. flammable gas monitoring.

Containers shall be stored upright, when designed for this, and measures taken to prevent them toppling over. Special arrangements may be required to secure small or round-bottomed containers.

Containers shall be grouped within the store according to a formal plan. This plan should take into account the hazards and the requirements of good storekeeping.

Used containers shall be segregated from full containers. They shall be clearly marked and stored in the same way as full containers.

Pyrophoric gas containers shall be separated from other categories of gas containers. It is preferable to use a separate store or a firewall. The minimum recommended separation distances in Table 4 shall apply.

The store shall be kept secure and access shall be restricted to authorised personnel. Some special gases require additional security measures e.g. very toxic gases, where the store is kept locked and the access keys are held by authorised personnel. Arrangements shall be made for unlocking the store in the event of an emergency.

The container inventory should be managed to ensure that the oldest stock is used first. The inventory shall be regularly reviewed to ensure that stock holdings are not excessive and that there is a regular turnover of all containers. Many special gases are given a shelf life and this stock should be managed to ensure that all these gases remain within their shelf life. Stock holdings should be formally inspected on a regular basis paying particular attention to older stock. Gases for which the shelf life has expired, which are no longer required, or which are used / empty should be returned to the gas supplier as soon as is practicable.

An inventory shall be kept listing all high hazard special gas containers e.g. very toxic or pyrophoric gases, held on site, whether full, in use or nominally empty. This inventory should be updated each time deliveries / collections to / from site are made by the gas supplier. A periodic physical audit (at least annually) should be made on the inventory and any deficiencies recorded, investigated and a report made to management.

The hazard from certain special gases may require a physical audit by the gas supplier, on the customers premises, on a routine basis, to ensure the customer has appropriate stock control and storage procedures in place.

On any occasion when leakage, excessive corrosion or excessive damage is detected the container is to be quarantined and appropriate safety precautions taken. The container is to be returned to the gas supplier as soon as practical. As necessary, the advice of the gas supplier should be sought.

6.5 Internal storage

Gas containers should be stored in an external location, refer to Section 6.2. Internal storage within a building is not recommended and should not be considered for new locations for container stores. The exception is where it is necessary to maintain specific gas properties that can only be carried out in a controlled environment.

Where it is necessary to store containers internally, in addition to the other requirements detailed in Section 6, the following applies:

(i) A formal risk assessment shall be carried out. Consideration shall be given to the probability of fire, gas density, explosion risk from flammable gas, valve leakage, ventilation, access / egress, cylinder handling, gas detection, fire protection, exposure of personnel.

(ii) The number of containers shall be kept to a minimum.

(iii) Where practicable the store shall be constructed of non-combustible materials. The walls, floor and ceiling shall be manufactured from materials complying with BS 476 (32) *Fire tests on building materials and structures*. Where it forms part of a building, it shall be separated from the rest of the building by a wall of at least 30 minutes fire-resisting construction, preferably of brick or concrete.

(iv) The store shall be adequately ventilated as determined by the risk assessment.

(v) Any forced ventilation system shall be linked to a suitable visual / audible alarm system to warn of failure.

(vi) Consideration should be given to atmospheric monitoring within the store depending on the perceived risk. If required, an appropriate gas detection system is to be provided and installed.

7. HANDLING OF GAS CONTAINERS

Most accidents and injuries in the compressed gas industry occur whilst moving / manhandling gas containers. Examples include back strain, bruised fingers and feet, etc.

The Manual Handling Operations Regulations (4) require that an assessment of manual handling operations is conducted. Following the assessments, training should take place. Where the assessment indicates that the work exceeds guideline limits, wherever practicable the operation should be mechanised or handling aids provided. BCGA Guidance Note 3 (60) *Safe cylinder handling and the application of the manual handling operations regulations to gas cylinders*, defines the principles of safe practice for handling and moving cylinders and provides a basic understanding of the Manual Handling Operations Regulations (4) relating to gas cylinders. BCGA TIS 17 (65), *Model risk assessment for manual handling activities in the industrial gas industry*, can be used to assist in developing a site risk assessment.

7.1 Handling precautions

Personnel should:

(i) Be trained, as required within Section 13.3, following an assessment carried out as required by the Manual Handling Operations Regulations (4);

(ii) Take account of the total mass of the container (this can be very significant, especially if it contains a liquefied gas);

(iii) Beware of trapping fingers between containers whilst they are being moved;

(iv) Seek help and observe the correct lifting posture and method when it is necessary to lift heavy containers manually.

(v) Use a purpose-built trolley or other suitable device or technique for transporting heavy a heavy container, even for short distances, ensuring the container is adequately secured;

(vi) Ensure valve protection devices (e.g. valve covers, guards, etc.,) and valve outlet plugs or caps are fitted to containers whilst they are being moved;

(vii) Never permit oil, grease or other readily combustible substances to come into contact with valves or containers;

(viii) Check by suitable means that there are no leaks from the valve and beware of inadvertently opening container valves fitted with hand-wheels;

(ix) Ensure that suitable measures are taken to prevent upright containers from toppling over.

7.2 Personal protective equipment

Personal Protective Equipment (PPE) is to be provided as required by the Personal Protective Equipment at Work Regulations (10). PPE may only be considered as a control to achieve an acceptable level of residual risk after other levels of control have been addressed. The risk assessment will determine the requirement for the use of PPE. Where PPE is required a PPE Assessment is to be carried out. Refer to Section 13.2.

For cylinder handling, the appropriate use of protective gloves, safety footwear and eye protection is necessary. Boots with metatarsal protection are strongly recommended.

All PPE shall be maintained in good condition.

7.3 In-house transport of toxic gases

ADR (18) details the regulations for the carriage of toxic gases. Vehicle operators responsible for the distribution, delivery or collection of large loads of gas containers should use open vehicles that have plenty of natural ventilation. The vehicle should have a gas tight bulkhead separating the driver from the load. The use of closed vehicles should be avoided, but they may be used for a small number of containers of toxic gases if specifically designed for the purpose. Vehicles used for this purpose should have adequate ventilation with vents located to encourage a free flow of air through the load compartment.

NOTE: The HSE are producing guidance on the acceptable levels of ventilation inside vans transporting dangerous goods.

Gas containers should be left on board no longer than is required to make the journey and should be removed immediately the destination is reached.

Further information for toxic gases is available in EIGA Document 130 (49). General information on the carriage of gas cylinders is available in BCGA GN 27 (62), *Guidance for the carriage of gas cylinders on vehicles*.

8. GAS SUPPLY POINTS

Gas supply points are defined as the points where the connected gas containers and associated valves and fittings, etc., are housed.

8.1 Key principles

Each gas supply point shall be the subject of a formalised risk assessment. Gas supply points should be:

(i) Secure (but with clear access);

(ii) Well ventilated

(iii) Free from naked flames and unprotected electrical equipment which could act as sources of ignition;

(iv) Well separated from fire hazards and populated areas;

(v) Used exclusively for containers;

(vi) Clearly labelled with the name of the gas and principal hazard(s);

(vii) Well maintained;

(viii) Provided with arrangements to stop containers from falling over;

(ix) Provided with a means of remote isolation of the supply, as close as is practicable to the supply container where a hazard could arise from an uncontrolled gas release in the downstream equipment.

8.2 Location of gas supply points

Gas containers of toxic, corrosive, pyrophoric or flammable gases which are connected for use shall each have a separate supply point and be located as follows:

(i) External gas supply points in a safe place outside buildings, refer to Section 8.4. This is the preferred location for all gases;

(ii) Within purpose-built internal gas supply rooms, refer to Section 8.5;

(iii) Inside purpose-built gas cabinets, refer to Section 8.6.

It is recommended that containers of other gases are kept as above. However, they may be connected for use at points in the workroom provided attention is paid to the key principles above and the number of containers is kept to a minimum.

8.3 Precautions against gas release

Precautions shall be taken both to minimise the risk of gas release taking place, and to minimise the effects should any occur. The former is a matter of sound engineering and working practices as set out in this code. The latter requires giving attention to factors including:

(i) Quantity of gas in the supply container;

(ii) Maximum discharge flow rate from the supply gas container;

(iii) Dilution extent of toxic gas in the ventilation / extract system;

(iv) Location, height above ground of vent to atmosphere;

(v) Velocity of discharge to atmosphere; location of air intakes, buildings and people;

(vi) Gas scrubbing or other treatment techniques to deal with accidental releases (refer to Section 10) where necessary;

Where the processes or substances used are those which are defined within environmental legislation, the Waste Regulator (the Environment Agency or the environment agencies within your jurisdiction) and the Local Authority shall be consulted as appropriate. Refer to Section 13.6 on gas monitoring.

8.4 External gas supply points

This is the preferred location as there is usually good natural ventilation. Even outside, it is recommended that containers of very toxic gases should be enclosed inside a suitably ventilated enclosure or a gas cabinet as described in Section 8.6.

The area where the gas containers are connected should comply with the general principles of Sections 6.2, 6.3 and 6.4. A suitable enclosure for containers of hazardous gases (except where a cabinet is provided - see above) is a secure wire mesh cage located in a safe, well-ventilated place, with no ignition sources and away from occupied areas.

It is particularly recommended that pyrophoric gas containers are installed outside whenever this can be reasonably achieved. In the event of a leak of pyrophoric gas, a delayed spontaneous ignition may result, refer to Section 5.1.1. In a confined space this could lead to an explosion. If located in the open air where there is plenty of natural ventilation, pyrophoric gas containers need not be housed inside a cabinet.

Where necessary a limited number of gas containers, not containing very toxic gases, may be secured against building walls, provided that the requirements above, in Section 8.4, and the following are met:

(i) The area complies with the general principles of Sections 6.2, 6.3 and 6.4;

(ii) The wall is fire-resisting, to a minimum of 30 minutes in accordance with BS 476 (32);

(iii) The containers are away from windows, drains, air intakes, etc., to prevent the escape of gases into buildings and to protect the containers against fires within the building;

(iv) The containers are well ventilated.

Pyrophoric gas containers, which are connected for use, shall be separated from other gas containers (purge gas containers excluded) either:

(v) By a minimum distance of 2 metres, refer to Table 4; or

(vi) by a firewall, provided it does not significantly reduce the ventilation; or

(vii) by placing them inside ventilated gas cabinets, refer to Section 8.6.

8.5 Internal gas supply rooms

Gas supply rooms comprise a separate room used solely to contain the supply gas containers and associated equipment. No other plant or machines shall be kept in these rooms and access shall be kept to a minimum and for authorised personnel only. Such rooms shall comply with the requirements of BCGA CP 4 (56), *Industrial gas manifolds and gas distribution pipework (excluding acetylene).*

In addition to the requirements below the general principles described for container storage in Section 6 also apply.

The numbers of containers in gas supply rooms shall be restricted to the minimum required for operational and standby / reserve purposes.

Gases and gas mixtures classified as pyrophoric and very toxic gases may be kept in internal gas supply rooms, provided they are enclosed in ventilated gas cabinets which meet the requirements of Section 8.6. It is recommended that ventilated gas cabinets be used for all toxic gases.

Where toxic gases are not housed in gas cabinets it shall be demonstrated that there is adequate ventilation and atmospheric monitoring to ensure that a safe working environment is maintained.

The airflow in the extract system shall be monitored and provided with a low / no flow alarm in case of failure. The alarm shall be audible or visible at the entrance to the gas supply room.

NOTE: For gas supply rooms containing heavier than air gases not housed in gas cabinets, the ventilation air should enter at high level and exit close to floor level in addition to any high level ventilation required for lighter than air gases.

Containers of inert purge gases serving gas supplies may be located in the same room as their appropriate process gas.

Where gas supply rooms are to be heated, this should be by indirect means, e.g. steam, hot water or warm air. Containers shall be protected from excessive heat, refer to Section 4.3. Measures taken shall not adversely affect the ventilation system.

For toxic, pyrophoric and flammable gases a clearly marked emergency isolation valve shall be provided on the gas supply system as close as possible to the container. The

emergency isolation valve shall be operable remotely from both outside and inside the gas supply room. This may take the form of a remotely operable cylinder valve.

For flammable gases, ignition sources shall be separated from potential sources of leaks, refer to Table 4. All equipment shall be electrically earthed. Electrical equipment shall be specified as in Section 6.3.

Although it is preferable for gas containers to be kept outside working areas, this may not always be practicable. In this case, gas cabinets fitted with forced draught ventilation may be used to keep gases inside the facility near to their point of use, or they may be located next to the machine using the gas in accordance with Section 8.2.

8.6 Gas cabinets

A gas cabinet is a purpose-built enclosure for the containment of gas supply containers. Refer to the BCGA policy statement on the use of gas cabinets at Appendix 1. Its function is to provide security, separation and localised ventilation. Gas cabinets used for the containment of toxic or flammable gases should:

(i) Be provided with forced air extraction ventilation which is safely discharged (for flammable gases the fan motor shall have a suitable ATEX rating or shall be excluded from the air stream);

(ii) Contain any purge gas supply container(s) associated with the toxic or flammable gas container(s) within the cabinet;

(iii) As far as is practicable, contain the pressure / flow control / purging equipment associated with the toxic or flammable gas supply container(s) within the gas cabinet.

Where practicable, gas cabinets should be separated from any other working areas by a wall of fire-resisting construction.

Used containers should be removed from the gas cabinet to an external storage area as soon as is practicable.

Spare full containers shall be stored in a purpose-built storage area (see Section 6).

Gas cabinets should be dedicated to a specific gas and should be shared only with their appropriate inert purge gas container. If this is not practicable, for gases other than pyrophorics, the gases shall be chemically compatible.

Gas cabinets shall be constructed of non-combustible materials. BS EN 14470-2 (42), *Fire safety storage cabinets. Safety cabinets for pressurised gas cylinders,* gives the performance requirements for fire safety cabinets used for storing pressurised gas cylinders.

The strength of the cabinet should be such that it offers sufficient support for the gas containers and associated equipment during normal use and container changing. The strength and mechanical integrity should not be unduly weakened under abnormal conditions likely to be encountered, e.g. a toppling container or local fire.

A suitable material to meet these requirements for cabinets containing more than one large (50 litre) container would be sheet steel of 2 mm nominal thickness. For cabinets housing flammable gases, the ventilation ducting shall be made of non-combustible material.

The cabinet door(s) shall be designed to give full opening to change containers and a smaller opening for valve manipulation.

Within the cabinet there shall be facilities to locate and secure the gas container to the cabinet.

All demountable joints shall be positioned inside the cabinet. All the associated valves, regulators and connections shall be adequately supported to avoid strain on joints and components during the connection and disconnection of containers.

Consideration shall be given for the provision of a water spray system at the top of the cabinet to cool the containers and associated equipment in the event of an external fire, and to prevent a fire from escalating.

There shall be a label and a hazard warning sign, in accordance with Health and Safety (Safety Signs and Signals) Regulations (6) / BS EN ISO 7010 (36), *Graphical symbols. Safety colours and safety signs. Registered safety signs*, displayed on each cabinet identifying the gas and its potential hazard. A further sign shall be displayed in the area in a clear and visible location, giving emergency information (including emergency telephone numbers, action to be taken in an emergency and a list of the gases present in the area).

Consideration shall be given to the monitoring of the air inside cabinets containing toxic gases and / or flammable gases (refer to Section 13.6).

The cabinet shall be provided with sufficient extraction ventilation to achieve the following:

- Prevent any escape of any hazardous gases to the workplace, with or without the valve manipulation window open;

- Maintain the potential concentration of flammable gases in the extracted air to below 25 % of the lower flammable limit, except in the event of a catastrophic leak.

The ventilation system shall be provided with a control and monitoring system of high reliability, to give warning of extraction ventilation failure.

Where flammable gases are connected, the cabinet and ventilation shall be designed such that the possibility of a flammable atmosphere inside the cabinet is prevented under normal operating conditions. Other precautions should be considered to cover abnormal conditions such as ventilation failure, catastrophic gas leak, etc. Suitable precautions could include one or more of the following:

- Exclude electrical equipment;
- Electrical equipment inside the cabinet meeting Zone 2 requirements;
- Automatic gas / electrical shutdown in the event of ventilation failure;
- Automatic gas / electrical shutdown coupled to a flammable gas detector.

The cabinet and all the equipment within the cabinet shall be electrically bonded to earth. This shall be separate from the electric power supply earth.

Gas cabinets may share the same extraction ducting providing the mixing of incompatible gases is not possible within the ducting and back feeding of an incompatible gas is not possible in the case of failure or shutdown of the extraction system.

9. GAS SUPPLY SYSTEMS

9.1 Key principles

All systems shall comply with the requirements of the PSSR (9), including having a current Written Scheme of Examination. For additional guidance refer to HSE Leaflet 122 (28), *Approved Code of Practice for the Pressure Systems Safety Regulations. Safety of Pressure Systems,* and BCGA CP 23 (57), *Application of the Pressure Systems Safety Regulations 2000 to industrial and medical pressure systems installed at user premises*.

Gas supply systems shall safely supply gas from the supply container to the point of use at the required pressure and flow without degradation of quality.

Gas supply systems shall be designed to ensure that cross-contamination of incompatible gases cannot occur between their systems and / or containers.

Gas supply systems shall be designed, installed, tested, inspected, commissioned and maintained to recognised codes by competent and suitably qualified engineers and technicians. Any modification to the systems or their designed mode of operation shall be properly authorised and documented. Advice and assistance can normally be obtained from reputable suppliers of equipment and gases, and guidance is given in BCGA CP 4 (56) and BCGA CP 23 (57).

All gas-wetted parts in the gas supply system shall be chemically compatible with the supply gas, in accordance with BS EN ISO 11114 (40), *Gas cylinders. Compatibility of cylinder and valve materials with gas contents*. The complete system shall be designed for the maximum foreseeable operating pressure, and subjected to appropriate pressure and leakage testing during commissioning. Gas supply system components should be stored in a clean, dry environment.

The principal components of a gas supply system include, among others, gas supply source, purging systems, pressure reducing regulators, flow limiting devices, over-

pressure protection devices, flow control valves, isolation valves, non-return valves, gas pipework, vacuum pumps, filters, purifiers.

9.2 Gas supply source

Gases will normally be supplied from transportable containers located in accordance with Section 8. This includes cylinders, tubes, bundles and drum tanks containing compressed or liquefiable gases.

9.3 Purging systems

Purging is necessary to maintain the integrity of the system under the following circumstances:

- During commissioning, to remove air and moisture from the system;
- During supply container changeover, to remove process gas or air and moisture from the container connection;
- For system maintenance purposes, to reduce process gas to a safe concentration level prior to opening the system and to remove air and moisture before re-introducing process gas;
- During an emergency, when it may be necessary to purge a gas quickly from the system.

Three purging techniques are commonly used:

(1) **Evacuation**;

(2) **Cycle purging,** where the system is alternately evacuated and pressurised with an inert purge gas for a specified number of cycles. The house vacuum system shall not be used. A dedicated vacuum system is recommended, such as a vacuum venturi operated by the purge gas (or dedicated external supply) or a vacuum pump;

(3) **Dynamic (or diffusion) purging**, where inert gas is purged through the system at a sufficient flow and for sufficient time. (Complete purging using this technique can be time-consuming, especially for complicated systems).

The purging techniques and the extent of purging will often be governed by quality requirements of the production process. However, for safety purposes:

- The oxygen content of systems prior to introduction of flammable gases shall not exceed 1 % v/v;
- Flammable gas systems shall be purged until the concentration of the flammable gas in the purge gas is less than 25 % of its lower flammability limit in air if known, or less than 0.1 % v/v in other cases;
- Toxic gases within piping shall be purged using any of the three techniques above, in such a way so as to ensure that, if piping is disconnected, concentrations

of toxic gases released do not present a health hazard. Refer to the workplace exposure limits in HSE EH 40 (24) and the appropriate Safety Data Sheet.

The following supply requirements apply:

- Purge gas sources should preferably be dedicated to single process gas applications to avoid back contamination (piped house supply nitrogen shall not be used). Where this is not practicable, purge gas should only be shared by compatible process gases;

- Purge gas supply containers shall be fitted with appropriate pressure reducing regulators and flow control valves;

- Purge gas supply system materials shall be chemically compatible with the process gas(es) being purged;

- If the process gas container is located inside a gas cabinet then the associated purge gas container should also be located within the same or other gas cabinet;

- The purge gas system, including the container, shall be capable of withstanding the maximum pressure that could be delivered from the process gas container (e.g. in the event of back feeding);

- A means shall be provided to ensure that sufficient purge gas is available to complete the purging operation (e.g. Pressure gauge and instruction to change purge gas container when a minimum specified pressure is reached);

The following procedural requirements apply:

- Precautions shall be taken to prevent contamination of the purge gas supply system and container with process gas;

- Precautions shall be taken to prevent the mixing of incompatible gases through the vacuum venturi or the venturi gas supply / vent system:

- Detailed instructions shall be provided for all normal and emergency purging operations:

- Purging should be carried out against a checklist to ensure all operations are properly and completely executed.

9.4 Pressure reducing regulators

Pressure reducing regulators are used to reduce and control the pressure from that of the supply source to that required by the process.

NOTE: Regulators do not control gas flow.

The choice of regulator depends upon:

- Compatibility with process gas;
- Supply pressure;
- Delivery pressure or required pressure range;
- Accuracy requirement of delivery pressure;
- Required flow range.

Regulators with metal diaphragms possess higher integrity than those fitted with non-metallic diaphragms and shall, therefore, be specified for toxic, pyrophoric and high purity gases and their associated purge gases.

Suitability of a regulator for a particular application shall be checked with the supplier.

9.5 Flow limiting devices

9.5.1 Automatic shut down

Supply systems for hazardous gases should include automatic shut-off devices which are actuated in the event of system failure or other emergency.

Examples of automatic shut-off devices include excess flow shut-off valves and remotely actuated gas container or supply valves. For very toxic and pyrophoric gases, supplied from a remote supply point, which is not normally manned, remotely operable isolation valves shall be fitted as near to the gas container as practicable. These shall be capable of activation from a readily accessible position. These valves may also be activated by gas monitoring or fire detection equipment or other means.

9.5.2 Flow limiting devices

In addition, where practicable, flow limiting devices should also be provided within or as near as possible to the gas container valve for all pyrophoric and / or very toxic gases.

The preferred type of flow limiting device is a flow-restricting orifice fitted in the container valve outlet (by arrangement with the gas supplier). The use of flow limiting orifices may not be appropriate for certain corrosive gases.

WARNING: Flow limiting orifices in the supply system will considerably reduce flow rates during purging operations. Excess flow shut-off valves normally require a bypass for purging purposes which, if left open, could negate the advantage of the shut-off valves in the event of down-stream line failure.

9.6 Over-pressure protection devices

Gas supply systems shall be designed to withstand the highest pressure that could foreseeably build up within the system. The use of over-pressure protection devices may be necessary. The danger of liquids or readily liquefiable gases giving rise to high

pressures should be considered. Release of gas or liquid shall be to a safe place refer to Section 10.

Five types of over-pressure relief devices are commonly available:

(1) Pressure sensor with automatic shut-off and / or vent valve. For very toxic and pyrophoric gases, the pressure sensor with automatic shut-off is the preferred device;

(2) Spring loaded relief valve - will re-seat when excess pressure has been relieved. Spring loaded relief valves shall be tested regularly to ensure that they relieve at the set pressure and reseal when the pressure is removed;

(3) Bursting disc - will not re-seat and will vent entire gas content of system, refer to Notes Section 9.6 (5) 2 below;

(4) Fusible plug - will be actuated by excess temperature and vent entire gas content of system.

NOTE: Fusible plugs do not provide total over-pressure protection.

(5) Barometric leg or lute - used for low pressure applications only (e.g. for gas disposal scrubbing system), will normally reseal when excess pressure has been relieved.

NOTES:
1. Seek advice from the gas and / or equipment supplier when selecting overpressure protection devices for hazardous gases.

2. On occasions the use of more than one relief device can be preferred, e.g. bursting disc discharging to relief valve often with pressure gauge between to indicate bursting disc failure.

9.7 Valves

General requirements for valves are:

- All valves shall be labelled to identify their function;

- Valves should be located in well-ventilated areas and away from air intakes. Remote operation should be considered;

- Where practicable, there should be a positive indication of the status of the valve, i.e. open or shut.

9.7.1 Flow control valves

Flow control valves are used to control gas flow through a supply system to a process. They can be used to open or isolate a gas supply or can control the gas flow rate in a pressure controlled system.

NOTE: Flow control valves do not control gas pressure and might not provide shut-off.

9.7.2 Isolation valves

Isolation valves are a means of positive isolation, in addition to the gas container valve, and shall be provided in each gas supply system as close to the source as possible. The means of operation shall be in an accessible position and clearly marked. This may require the possibility of remote operation.

9.7.3 Non-return valves

These valves are designed to permit flow in one direction only but shall not be relied upon as the sole means of isolation. They should be periodically checked for performance or replaced.

9.8 Pipework

9.8.1 Design and installation

Where practicable, all joints in pipelines should be made by non-mechanical means, i.e. by welding, brazing or silver soldering. This is particularly important for:

- Pipelines carrying very toxic or pyrophoric gases;
- All pipelines located in inaccessible places;
- Where gas quality is critical.

Where mechanical joints are used, care shall be taken to ensure that the joints are correctly assembled using only compatible components. Particular care shall be taken when components from different manufacturers are being assembled into the same system. Rigorous cleaning of all sections prior to installation and subsequent capping of all open ends before and during construction is necessary to ensure absence of contamination within the finished system.

Failure to properly clean pipework could result in one or more of the following:

- Risk of fire in oxidant gas service;
- Particulate contamination adversely affecting valve seats;
- Shortening of the life of point of use filters and other downstream equipment;
- Presence of moisture resulting in corrosion within the system;
- Presence of air in systems resulting in oxide build-up within system components, e.g. silica in systems handling silanes.

Other requirements include a general requirement that the design and location of pipework shall comply with BCGA CP 4 (56), and in particular:

- Pipework systems shall be adequately earthed where a static discharge could ignite flammable substances;

- Pipework shall be adequately supported using materials which will not give rise to electrolytic corrosion;

- Systems shall comply with the PSSR (9). For additional guidance refer to HSE L 122 (28) and BCGA CP 23 (57);

- Underground pipework shall be adequately protected against damage, e.g. by corrosion or by external load.

NOTE: Underground pipelines are not recommended for very toxic, pyrophoric and corrosive gases because of the difficulties in inspection and maintenance;

- Ducts or channels carrying pipework shall be well ventilated;

- Pipework shall not be installed in ventilation shafts;

- Pipework shall not be installed in confined spaces where leakage could give rise to hazards, e.g. Lift shafts, confined roof spaces, etc.;

- Pipework shall be installed such that the possibility of mechanical damage is minimised;

- Pipework shall be protected from external corrosion and excessive heat;

- Suitable sleeves shall be used where pipework passes through building fabric;

- Pipework carrying flammable or toxic gases should be routed outside buildings, where practicable. Where this is impracticable purged sleeving should be considered. Piping should be sized (bore and length) so as to minimise the quantity of flammable or toxic gas in the system.

9.8.2 Pressure Testing

Pressure testing of systems shall comply with the requirements of BCGA CP 4 (56), including certification.

9.8.3 Inspection prior to commissioning

This should be undertaken after pressure testing as required by the design code and should include:

- The final visual inspection of the total system to ensure compliance with design and absence of damage;

- A leak test at 110 % of the maximum operating pressure using an inert gas and a detection system appropriate to the specified leak rate acceptance criteria for the process gas concerned.

- Where the test necessitates the removal of vulnerable equipment (e.g. pressure gauges, relief valves etc.) a final leak test at an appropriate pressure should be carried out after their reinstatement.

- A record shall be kept of the leak testing carried out.

NOTE: Never attempt to tighten leaking joints in gas supply systems whilst the gas system is under pressure.

9.8.4 Identification of pipework service

Pipework shall be labelled with its gas service at appropriate points along the system and at points of access. Care should be taken to ensure that the method of fixing the labels (e.g. clips, adhesives, etc.) does not damage or corrode the pipeline.

9.9 Vacuum pumps

9.9.1 Vacuum pumps selection

Vacuum pumps should be selected and installed in conjunction with the pump manufacturers to ensure:

- Chemical compatibility of components and lubricants with the process gas;

- Design suitability for the intended application (e.g. flow rate, containment of hazardous gases, provision of pump case purges, process gas quality);

- Compatibility with the electrical zone classification of the area in which the pump will be sited, refer to Section 6.3.

9.9.2 Siting

In the siting of a vacuum pump, provision shall be made for:

- Adequate access for maintenance and checking;

- Catchments for any oil leakage or spillage;

- Collecting oil during oil changes;

- Ventilation, including allowance for any extra hazards such as process gas absorbed in oil when maintenance work is in hand;

9.9.3 Leak testing

Vacuum pumps handling hazardous gases shall be included in the leak testing inspection carried out on the gas supply system. This shall include leak tests on the pump itself and on the exhaust from the pump to the safe discharge point.

9.9.4 Gas ballast

Where hazardous gases or gases likely to condense or introduce solids are used a suitable gas ballast into the vacuum pump should be considered.

Means are required to ensure that the flow of ballast gas is maintained. A clearly visible flow indication is a minimum requirement, preferably with an alarm or automatic cut-out if the ballast flow is interrupted. Non-return valves shall be fitted to all gas ballast feed-lines.

Where corrosive gases are used, the pump and the flow of ballast gas needs to be operated in such a way that the corrosive environment is removed from the pump.

9.9.5 Exit gas arrangements

The exit pipe from the vacuum pump shall incorporate safety features to cater for fire, explosion and toxic hazards for all hazardous gases. It shall be designed to:

- Take special account of the requirements resulting from the use of common exit lines;
- Be free from any leaks which could give rise to an external hazard, or ingress of air sufficient to give a fire or explosion risk in the system;
- Avoid features such as negative gradients, traps, loops or corrugations where fluids cannot be drained;
- Incorporate where possible a nitrogen feed into the exit line to make it possible to fill the whole of the exit line with nitrogen before admitting process exhaust gas. The anti-suck-back valves commonly fitted to oil-based vacuum pumps shall not be used when the pump is used for pyrophoric gases, as these do not prevent air ingress;
- Allow appropriate disposal arrangements where necessary for all exit gases (refer to Section 10);
- Be constructed from non-combustible materials where flammable gases are being exhausted.
- Use appropriate diameter of tubing to avoid back pressurisation.

9.9.6 Cold traps

Where cold traps are used in conjunction with vacuum pumps they can present problems by condensing and hence concentrating hazardous compounds, including any which may have been formed by the processes involved. There is also a danger if oxygen from the atmosphere is allowed to enter the system and

condense in a trap cooled by liquid nitrogen. Cold traps shall not be used in conjunction with pyrophoric gases.

When it is necessary to empty a cold trap, provision shall be made for preventing exposure of personnel to toxic fumes. Some condensed compounds could react with components of the atmosphere and form other hazardous products. Where this possibility exists, precautions are needed to avoid access of the atmosphere to the contents of the trap. Arrangements shall be made for the safe disposal of hazardous materials from cold traps.

9.10 Special requirements for silane and other pyrophoric gases

NOTE: While this section refers only to silane the principles apply equally to other pyrophoric gases.

Silane does not always ignite spontaneously when brought into contact with air. It may mix with the air to form an unstable mixture which may subsequently explode with considerable force. For additional guidance on silane refer to EIGA Document 160 (52), and USA CGA G-13 (69), *Storage and handling of silane and silane mixtures*.

Special attention is drawn to the following:

(i) Always store silane at a positive pressure and avoid condensing silane. Air or other oxidant leaking into systems containing silane could result in explosion or could react slowly with silane, depositing silica and causing possible failure of regulators, non-return valves, etc.

(ii) Always ensure air or other oxidant gases are purged out of systems before introducing silane. If this is not done, an explosion or fire may occur. In addition silica dust will be produced which may block or cause failure of the pressure and flow control equipment, including non-return valves. This precaution also applies to silane vent and disposal systems;

NOTE: Serious incidents, including fatalities, have occurred when silane and nitrous oxide for example have inadvertently mixed due to component failure.

(iii) Always design and test all systems handling silane to:

- Minimise the risk of leakage;
- Maximise the ease with which they can be efficiently purged;
- Enable easy isolation of the silane supply if a leakage (or other problem) occurs;
- Eliminate “dead” spaces which may be difficult to clean/purge;
- Minimise internal volume.

(iv) Always use non-combustible materials to construct those gas cabinets / ventilation systems, etc., which may contain silane;

(v) Never enclose silane handling equipment inside unventilated cabinets or enclosures. Leakage of silane into unventilated spaces could result in explosion and rupture of the enclosures. (This includes the removal of backplates from pressure gauges / rotameters, etc.);

(vi) Never allow silane to contact even small amounts of halogens or heavy metal halides. This includes ensuring all components of the silane handling system are purged free of halogens that might derive from degreasing agents or halogenated hydrocarbons.

These precautions shall also be applied to other pyrophoric gases.

9.11 Special requirements for oxygen and other oxidants

NOTE: While this section refers only to oxygen the principles apply equally to other oxidant gases, some of which have a higher oxidising potential than oxygen. For example, refer to EIGA Document 92 (48), *Code of Practice, Nitrogen Trifluoride*.

Oxygen will propagate the combustion of many materials, including the steel and aluminium alloy components of gas systems, once an ignition has occurred. Ignition energies required for common flammable materials such as oils, greases and some plastics, etc., are extremely low in an oxygen-enriched atmosphere.

Examples of circumstances, which have led to ignition of components in oxygen or oxidant service, are:

- A small particle in a high velocity gas stream.

- Adiabatic compression caused by rapid opening of valves (heat sinks or slow operating valves can be used to prevent this problem).

Pipework and systems for handling oxygen shall be degreased and free from particulate contamination. All materials in the system shall be suitable for oxygen service. Special attention shall be paid to the suitability of sealing materials and plastic components that may be found in valves, pressure regulators, etc. For details consult your gas supplier.

Systems for all other oxidants require the precautions given above. In addition, for the more powerful oxidants (e.g. fluorine and chlorine trifluoride) the system shall be made passive prior to use with a dilute mixture of the oxidant in accordance with the gas supplier’s instructions.

Normal explosion-protected electrical apparatus is not to be assumed as being necessarily suitable for use in oxygen, or other oxidant, enriched atmospheres. Electrical apparatus for use in these areas shall be given special consideration.

10. DISPOSAL OF WASTE GASES

10.1 Disposal arrangements

Discharges may be subject to controls under the Environmental Protection Act 1990. (2) or other environmental legislation in your geographical area. Guidance on environmental aspects of disposal is given in the Semiconductor Environmental Safety and Health Association (SESHA) Environmental Code of Practice for the Micro-electronics Industry (71) and the EIGA Document 30 (45), *Disposal of Gases*.

All waste gases must be disposed of in a manner which will not endanger people or harm the environment.

The disposal of waste gases may be considered under two general categories:

10.1.1 Routine

Those waste gases which occur on a regular basis as part of the process. Toxic or very toxic gases shall not be routinely discharged directly to atmosphere - such gases shall be treated by appropriate processes.

10.1.2 Non-routine

Those waste gases which may occur infrequently, such as in the event of an emergency release. Consideration shall be given to the means of treating, controlling and discharging potential non-routine gas releases so as to ensure there is no danger to people.

NOTE: Toxic or corrosive compounds can be formed from non-hazardous gases during processing.

10.2 Discharge to atmosphere

Where waste gases are discharged directly to atmosphere, the principles set out in Table 5 shall be observed.

10.3 Abatement equipment - treatment techniques

The efficacy of all abatement equipment shall be monitored, preferably continuously, to ensure permitted emission levels are not exceeded. The abatement equipment is likely to be based on one or more of the following treatment techniques. Choice will be determined by considerations of safety, the effect on the environment, and the need to comply with regulations.

10.3.1 Incineration

The waste gas is mixed with air and passed through a separately fuelled burner or heated chamber, operating at a suitable temperature well in excess of the auto-ignition temperature of the waste gas so as to ensure complete oxidation.

The properties of the resultant oxidised material, which may be gaseous, liquid or solid, shall be considered with a view to establishing further treatment required for its safe disposal. Gaseous waste may require chemical scrubbing. Liquid and solid wastes may need to be referred to a specialist disposal contractor.

Hazardous Property of Gas	Principles	
Toxic and Harmful	**Routine:**	Discharge via appropriate process equipment. Monitor efficiency of equipment.
	Non-routine:	Consider means of treating, controlling and discharging. If discharged to atmosphere, must be to a safe place and diluted with air so as to ensure people are not exposed to levels in excess of the Workplace Exposure level. Refer to HSE EH 40 (24).
Flammable gases	**All disposal operations**	Avoid risk of explosive gas / air mixtures in equipment and the workplace. Avoid ignition sources where there is a risk of unintended flammable gas ignition. If discharged directly to atmosphere, must be to a safe place, away from personnel and air intakes. The fitment of flash-back arrestors should be considered. Consider electrical classification of the area.
Oxygen and Oxidants	**All disposal operations**	Avoid oxidant enrichment of the atmosphere which could enhance fire propagation.
Asphyxiant gases	**All disposal operations**	Avoid atmospheric oxygen depletion which could result in an asphyxiant hazard.

Table 5: Waste gas discharge to atmosphere

10.3.2 Chemical absorption

Reactive gases can be removed from a waste gas stream by a suitable liquid or solid state chemical scrubber. The design of such equipment is largely dependent on the reactive gas concentration, flow rate and rate of reaction of the waste gas. Generally, equipment to remove low flow rates with high concentrations of reactive gases are simpler and less expensive than equipment designed to handle high flow rates such as those which air extraction systems may deliver. It is, therefore, desirable wherever practicable, to treat reactive waste gases before dilution with air.

The chemical reagents used in all such equipment shall be closely monitored to ensure efficacy. The spent chemical scrubber material, which may be liquid or solid or a mixture of both, must be disposed of safely. Such material may need to be referred to a specialist disposal contractor.

10.3.3 Adsorption

Some waste gases can be adsorbed on suitable adsorbent materials such as charcoal and molecular sieve.

Where adsorption is considered as a means of treating waste gases, the following must be taken into account:

- Heat may be generated during adsorption;
- Adsorbed gases may be released if the adsorbent material is heated;
- The adsorbent should be purged with an inert gas before use, particularly if the waste gas or the adsorbent material is flammable, e.g. Charcoal;
- There may be a fire risk if the spent adsorbent containing some gases, e.g. phosphine, is exposed to air. Where such a risk is thought to exist, special precautions shall be taken to ensure air is excluded by the use of an inert gas atmosphere during transfer and packing of the spent adsorbent;
- Personnel handling adsorbent material shall wear adequate personal protective equipment. Hazards may include dust, toxic fumes and corrosivity;
- Spent adsorbent material shall be placed in a sealed container and referred to a specialist disposal contractor;
- Oxidant gases shall not be adsorbed on charcoal.

Further advice on the disposal of waste gases can be found in the EIGA Document 30 (45).

11. OPERATING PRINCIPLES FOR GAS SUPPLY SYSTEMS

11.1 Key principles

Key principles for gas container connection and disconnection include:

- Provision of appropriate training and supervision;
- Positive identification of the container;
- Provision and use of appropriate personal protective equipment;
- Ensuring the presence of back-up personnel for toxic / pyrophoric gases;

- Ensuring that sufficient inert purge gas is available;

- Reporting any gas container leakage;

WARNING: Never attempt to tighten leaking joints whilst the pipework system is under pressure. First depressurise the system (and if appropriate purge with inert gas) returning it to atmospheric pressure before tightening the joint.

NOTE: For the connection and disconnection of gas containers, the use of a check list is recommended to ensure procedures are correctly followed, all necessary safety precautions are taken and all valve outlet plugs / caps, valve protection devices, etc., are fitted prior to removing from the supply point.

11.2 Connection of the gas container

When connecting a gas container:

(i) Secure the gas container at the supply point before removing the valve protection device;

(ii) Ensure that the valve is closed and no visual signs of damage are present before removing the valve outlet plug / cap nut;

(iii) Ensure that the valve outlet and supply point connections are clean and undamaged before connecting to the supply point;

(iv) Purge and leak test in accordance with the system operating procedure, before opening the gas container valve.

When the gas container is ready for use open the gas container valve slowly. Check pressure, flow, etc., to ensure the system is operating in accordance with system operating procedures. It is recommended practice to check and record these parameters regularly.

11.3 Disconnection of the gas container

When disconnecting a gas container:

(i) Ensure that the gas container valve is closed.

(ii) Ensure that the system is shut down and purged of hazardous gas, in accordance with system operating procedure, and re-check that the gas container valve is closed before disconnection.

(iii) Fit a protective device to the supply point connection to prevent contamination if the replacement gas container is not being connected immediately.

(iv) When the gas container is disconnected, leak check the gas container valve outlet and refit the outlet plug / cap and valve protection device (where supplied).

(v) Contact the gas supplier in the case of inability to fit securely the valve outlet plug / cap or valve protection device; or

- if any leakage is detected; or

- if there is any suspected contamination which may have occurred during use.

Do not remove from supply point until advised to do so by the gas supplier.

The nominally empty gas container should be moved as soon as practicable to the 'used container store'.

NOTE: The container will still contain residual gas and is not to be regarded as empty.

12. PLANT MAINTENANCE

12.1 General precautions

Planned, regular preventive maintenance of all equipment used to control hazards is required by the COSHH (11) Regulations. It is, in any case, necessary to ensure that the continued efficiency and integrity of a gas handling plant is maintained. This includes supply systems, vacuum systems, disposal systems and ventilation equipment. The frequency and method of maintenance operations will depend on manufacturer's recommendations and user's experience. Any specific instructions issued by manufacturers shall be followed. The COSHH (11) Regulations set out specific needs for checking and maintenance in relation to all control measures, particularly with ventilation.

Where the installation is a pressure system as defined by the PSSR (9), the requirements for maintenance and examination given in these regulations shall also be taken into account.

Maintenance work shall not be attempted unless all the appropriate knowledge, skills, experience and specialised tools, etc., are available and 'work permit' forms have been issued, refer to Section 12.2.

12.2 Permit to work

A permit to work form shall be used to cover all maintenance work on systems and in areas where a hazard may exist. Requirements for the issue of a permit to work include that it shall:

(i) Be issued by the authorised person with direct responsibility for the system or area to a named person who will be doing or personally supervising the work;

(ii) Certify that the system / area has been made safe for the maintenance work to proceed and detail how this has been done;

(iii) Specify any further tests, precautions, etc., necessary during the valid period of the work permit;

(iv) Specify personal / protective equipment to be used;

(v) Only be issued for a defined period (normally only one day or shift);

(vi) Detail any necessary restrictions on personnel entering the area;

(vii) Detail or refer to other instructions or checks to be carried out after completion of maintenance work before handover to normal operating staff;

(viii) Detail or refer to other instructions on the treatment and disposal of waste materials removed from the system (e.g. contaminated lubricants, system components);

(ix) Detail any backup arrangements necessary to ensure the safety of maintenance personnel;

(x) Give details of actions in the event of an emergency;

(xi) Only be varied by the originator, and then it shall be revalidated in accordance with the above, before re-issue;

(xii) All gas systems shall be made safe before any plant maintenance work commences. This includes:

- Depressurising the system;

- Purging / testing to ensure all hazardous materials have been removed from the system and safely disposed of;

- Isolation of gas supplies to the system using a minimum of two valves or other high integrity means. The isolation valves should be locked in the closed position and labelled appropriately.

NOTES:

1. A permit-to-work will be specific in its reference to the precautions and hazards associated with the task to be undertaken. It is also important that the general hazards of the area are not forgotten.

2. For further guidance on permit to work systems refer to HSE HSG 250 (26), *Guidance on permit-to-work systems. A guide for the petroleum, chemical and allied industries*, and EIGA Document 40 (46), *Work Permit Systems*.

13 SAFETY

13.1 Fire safety

A Fire Safety Risk Assessment shall be carried out on all storage sites and is to be incorporated into the Site Fire Safety Management Plan. Each site should keep a record of the location of its hazardous store(s), this is to be made available to the emergency services in the event of an incident. Refer to The Regulatory Reform (Fire Safety) Order (13).

Special gases may require additional precautions to be applied when fighting a fire. The location of special gases is to be clearly designated and shown on the site plan. The emergency services are to made aware of the additional hazards which may be encountered with special gases;

Fire fighting facilities as identified in the risk assessment for the storage facility shall be provided. Consideration is to be given to the volume and pressure of available water. Refer to BS 5306 (35), *Fire extinguishing installations and equipment on premises.*

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

Wherever practicable, the storage infrastructure should be constructed of non-combustible materials.

All gas storage areas shall be designated as "**NO SMOKING"** areas. Suitable signs are to be displayed.

Appropriate emergency procedures shall be drawn up based on the findings of the Fire Safety Risk Assessment. Refer to Section 13.6 for further information on an emergency response plan.

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

For all stores an appropriate number and type of extinguishers shall be provided and correctly located. Fire extinguishers should be positioned in a readily accessible position close to the exits. Additionally, positive pressure breathing apparatus, a water shower and eye wash bottle may be required, refer to Section 13.2.

13.2 Personal protective equipment

13.2.1 General requirements

Personal Protective Equipment (PPE) is to be provided as required by the Personal Protective Equipment at Work Regulations (10). PPE may only be considered as a control to achieve an acceptable level of residual risk after other levels of control have been addressed. The risk assessment will determine the

requirement for the use of PPE. Where PPE is required a PPE Assessment is to be carried out. Due regard is to be given to the requirements of the COSHH (11) Regulations, any relevant equipment publications, manufacturers information and the product Safety Data Sheet. The PPE selected is for a particular task and location and must be appropriate and chosen to reduce the overall risk effectively. Thus there are different PPE requirements for differing products and different tasks.

HSE L25 (27), *Personal Protective Equipment at Work,* provides guidance on the Personal Protective Equipment at Work Regulations (10). EIGA Document 136 (51), *Selection of personal protective equipment*, provides guidance for selecting and using PPE at work.

PPE shall be provided for the use of all personnel involved in handling gas containers and operating / maintaining gas handling equipment, supply and disposal systems.

Requirements for the use of such protective equipment shall be clearly defined in the operating instructions.

All PPE shall be stored in clearly marked areas which are away from areas likely to become contaminated. Where appropriate e.g. self-contained breathing apparatus, equipment should be stored in containers and in the manner recommended by the supplier.

Adequate spare equipment should be available to replace equipment removed for maintenance or repair. Any unserviceable equipment should be clearly labelled and personnel advised of its non-availability.

Recommended PPE is detailed in Table 6.

13.2.2 Maintenance of personal protective equipment

All personal protective equipment shall be inspected regularly against a check list, to ensure that it is kept in good functional condition, is in the designated storage area, and is ready for immediate use. Inspections shall be recorded.

Portable Monitors shall be calibrated and checked regularly in accordance with the manufacturer's instructions.

Self-contained breathing apparatus shall be regularly cleaned and checked to ensure correct operation and air container / spare air container(s) are fully charged. Refer to BS EN 529 (33), *Respiratory protective devices. Recommendations for selection, use, care and maintenance. Guidance document.* Such maintenance should also be carried out each time the equipment is used. If an in-house air container charging facility is available it shall be regularly maintained in accordance with the manufacturer's instructions. Air quality is to the specification in BS EN 12021 (36), *Respiratory protective devices. Compressed air for breathing apparatus*.

Activity	Recommended PPE
Handling gas containers:	• Safety footwear. • Heavy duty gloves. • Safety eye / face protection.
Handling gas containers or operating gas supply systems:	Flame retardant clothing with flammable, pyrophoric and oxidising gases.
For prevention of ignition risk:	• Anti-static soles on footwear. • Anti-static clothing. • Anti-spark tools.
For protection against potential gas leakages:	• Portable toxic gas monitor. • Portable oxygen enrichment/depletion monitor. • Positive pressure breathing apparatus (only to be used by persons who are adequately trained and checked as being medically fit). • Portable flammable gas monitor.
When handling corrosive chemicals:	• Face shield / goggles. • Chemically-resistant gauntlets. • Chemically-resistant apron or overalls. • Chemically- resistant boots.
For emergency use:	• Self-contained, positive pressure breathing equipment (e.g. to BS EN 529 (33) with an adequate supply of spare air containers. • Face shield. • Chemically-resistant gauntlets. • Complete body protection suit (e.g. for area contaminated with corrosive gas). • First aid equipment, including eye wash and shower. • Fire extinguishing equipment - water hose systems, carbon dioxide and dry powder.

Table 6: Recommended PPE

13.3 Training

All personnel involved in the handling of gas containers and the operation and maintenance of gas supply and disposal systems shall be trained to a level appropriate to their involvement. Training shall be planned, recorded and regularly reviewed and updated, and shall be undertaken against documented operating and safety procedures. Trainees shall be checked to ensure they have a full understanding of the topics / material on which they have been trained and such checks shall be recorded and signed by both trainer and trainee.

Training topics include:

- The requirement for safe working, which is a general duty for all personnel as set out in the Health and Safety at Work etc. Act (1). Site safety rules and company safety policy (e.g. when and where protective equipment shall be worn, designation of no smoking / smoking areas, when a "Permit to Work" is required);

- Gas container handling;

- Gas container contents identification and hazard identification;

- Gas properties (physical, chemical, hazardous);

- Potential hazards of high pressure containers, equipment and systems;

- Gas container changing and associated purging procedures;

- Gas supply, disposal and associated equipment (physical layout, operation and maintenance);

- Personal protective equipment (selection, location and use);

- Emergency equipment (location and use);

- Emergency procedures (site evacuation in event of gas leak or fire, plant shutdown, etc., refer to Section 13.5);

- Maintenance and "Permit to Work" procedures;

- Atmospheric monitoring equipment;

- Safety checks on gas containers on receipt and before return to suppliers.

13.4 Standard operating procedures

Written standard operating procedures with relevant engineering drawings covering all aspects of safe handling of gases and associated plant and equipment shall be available. Standard operating procedures shall be prepared by competent personnel, formally approved and regularly reviewed and updated. A system shall be followed to ensure that only the latest issued standard operating procedures and drawings are in use and that new plant or modifications to existing plant are not put into use until standard operating procedures and drawings have been issued or revised.

13.5 Audits

Regular audits shall be carried out and recorded. Particular requirements to be included are that:

- All operations are covered by authorised procedures;

- Latest issue of all drawings, standard operating procedures and relevant Safety Data Sheets are readily available;

- All standard operating procedures are being followed;

- Unauthorised modifications have not been made to the systems and procedures;

- All personnel are adequately trained. It is the duty of the employer to establish competency. All training should be formally recorded. Periodic retraining is strongly recommended;

- All safety and emergency protective equipment specified is available and in good condition.

13.6 Emergency response plan

There shall be a published emergency response plan which is periodically practised. This plan shall take account of all potential hazards and all safety and legal requirements relating to the gases (and other materials), processes and equipment, etc. The plan shall have a primary regard to the safety of personnel. In drawing up the plan reference may be made to EIGA Document 80 (47), *Handling gas container emergencies*.

NOTE: This document is primarily intended for gas suppliers.

Key points for consideration when formulating the emergency response plan include the following:

(i) Alarm systems;

(ii) Plan for site evacuation and roll call;

(iii) Consultation and communication with the emergency services (e.g. Fire & Rescue Service, ambulance, police, local hospital, gas / other suppliers, etc.);

(iv) Search for unaccounted personnel;

(v) Evacuation of affected personnel via prepared evacuation routes;

(vi) Safe emergency shutdown of equipment and processes;

(vii) Consultation and communication with neighbours;

(viii) Communication with media;

(ix) Procedure for advising personnel that areas are safe for re-entry;

(x) Evaluation of hazards associated with gas escapes;

(xi) Site emergency response team including individual's medical fitness, responsibilities, means of communication and backup when entering hazardous area;

(xii) Provision, location, regular checks and personnel training in the use of emergency equipment (e.g. fire fighting equipment, first aid requisites, breathing apparatus and special protective clothing);

(xiii) Re-instatement of emergency equipment after use;

(xiv) Provision of site plans showing location of hazardous materials and emergency equipment;

(xv) Provision of safety data on all hazardous materials;

(xvi) The plan should also cover out-of-normal working hours;

(xvii) Formal training and updating of those involved in the emergency response team;

(xviii) Response to power failure and power back up requirements.

(xix) After conclusion of emergency prepare report to authorities.

13.7 Hazardous gas monitoring

Monitoring equipment shall be considered where there is a foreseeable risk of a gas escape causing injury or environmental damage.

The output from the gas detection system can offer two warnings:

(i) **Level One:** Give an audible / visual alarm to warn personnel to take the appropriate emergency / corrective action prior to dangerous concentrations being reached.

(ii) **Level Two:** Give an audible / visual alarm to warn personnel to shut off the gas supply or to trigger automatic shut-down procedure.

Records of testing and calibration of the equipment shall be kept.

Where asphyxiation is identified as a potential hazard, consideration shall be given to the installation and use of oxygen monitoring equipment.

Further information on gas monitoring is provided in the HSE HSG 173 (25), *Monitoring strategies for toxic substances*, and the HSE MC series of publications providing guidance on the COSHH (11) Regulations in the microelectronics industry, e.g. HSE MC0 (30), *COSHH essentials for the microelectronics industry. Advice for managers.*

14. REFERENCES

Document Number		Title
1		Health and Safety at Work etc. Act 1974.
2		Environmental Protection Act 1990.
3	SI 1990 No. 304	The Dangerous Substances (Notification and Marking of Sites) Regulations 1990.
4	SI 1992: No. 2793	Manual Handling Operations Regulations 1992 (as amended).
5	SI 1996 No. 192	The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations (EPS).
6	SI 1996: No. 341	The Health & Safety (Safety Signs & Signals) Regulations 1996
7	SI 1999: No. 743	Control of Major Accident Hazards Regulations 1999 (as amended) (COMAH).
8	SI 1999: No. 3242	Management of Health and Safety at Work Regulations 1999.
9	SI 2000: No. 128	Pressure Systems Safety Regulations 2000 (PSSR)
10	SI 2002: No. 1144	Personal Protective Equipment at Work Regulations 2002.
11	SI 2002: No. 2677	Control of Substances Hazardous to Health Regulations 2002 (COSHH).
12	SI 2002: No. 2776	The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR).
13	SI 2005: No. 1541	Regulatory Reform (Fire Safety) Order 2005.
14	SI 2009: No. 716	The Chemicals (Hazard Information and Packaging for Supply) Regulations 2009. (CHIP 4)
15	SI 2009: No. 1348	The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (as amended).
16	United Nations ST/SG/AC.10/1	UN Recommendations on the Transport of Dangerous Goods, Model Regulations.
17	United Nations ST/SG/AC.10/30	UN Globally Harmonised System of Classification and Labelling of Chemicals (GHS)

Document Number		Title
18	European Union ECE/TRANS/225	European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)
19	European Directive 67/548/EEC	European Directive on the classification, packaging and labelling of dangerous substances (as amended).
20	European Directive 94/9/EC	European Directive on the approximation of the laws of Members States concerning equipment and protective systems intended for use in potentially explosive atmospheres. Also known as 'ATEX 95' or the 'ATEX Equipment Directive'.
21	European Directive 99/92/EC	European Directive on minimum requirements for improving the health and safety protection of workers potentially at risk from explosive atmospheres. Also known as 'ATEX 137' or the 'ATEX Workplace Directive'.
22	EC Regulation No 1272/2008	European Regulation on the Classification, Labelling and Packaging of Substances and Mixtures (CLP).
23	EC Regulation No 1907/2006	Registration, Evaluation, Authorisation and restriction of CHemicals (REACH).
24	HSE Guidance Note EH 40	Workplace Exposure Limits.
25	HSE HSG 173	Monitoring strategies for toxic substances.
26	HSE HSG 250	Guidance on permit-to-work systems. A guide for the petroleum, chemical and allied industries.
27	HSE L25	Personal Protective Equipment at Work. Personal Protective Equipment at Work Regulations 2002. Guidance on regulations.
28	HSE L122	Approved Code of Practice for the Pressure Systems Safety Regulations. Safety of Pressure Systems.
29	HSE L138	Dangerous substances and explosive atmospheres. DSEAR 2002. Approved Code of Practice and guidance.
30	HSE MC0	COSHH essentials for the microelectronics industry. Advice for managers.
31	BS 341	Transportable gas container valves.
32	BS 476	Fire tests on building materials and structures.

Document Number		Title
33	BS EN 529	Respiratory protective devices. Recommendations for selection, use, care and maintenance. Guidance document.
34	ISO 5145	Cylinder valve outlets for gases and gas mixtures. Selection and dimensioning.
35	BS 5306	Fire extinguishing installations and equipment on premises.
36	BS EN ISO 7010	Graphical symbols. Safety colours and safety signs. Registered safety signs.
37	BS 7671	Requirements for electrical installations. IET wiring regulations.
38	BS EN ISO 10156	Gases and gas mixtures - Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets.
39	BS ISO 10298	Determination of the toxicity of a gas or gas mixture.
40	BS EN ISO 11114	Gas cylinders. Compatibility of cylinder and valve materials with gas contents.
41	BS EN 12021	Respiratory protective devices. Compressed air for breathing apparatus.
42	BS EN 14470 Part 2	Fire safety storage cabinets. Part 2. Safety cabinets for pressurised gas cylinders.
43	BS EN 60079 Part 14	Explosive atmospheres. Electrical installations design, selection and erection.
44	BS EN 60529	Specification for degrees of protection provided by enclosures (IP code).
45	EIGA Document 30	Disposal of gases.
46	EIGA Document 40	Work permit systems.
47	EIGA Document 80	Handling gas container emergencies.
48	EIGA Document 92	Code of Practice, Nitrogen Trifluoride.
49	EIGA Document 130	Principles for the safe handling and distribution of highly toxic gases and mixtures.
50	EIGA Document 134	Potentially explosive atmospheres EU Directive 1999/92/EC.

	Document Number	Title
51	EIGA Document 136	Selection of personal protective equipment.
52	EIGA Document 160	Code of Practice, Silane.
53	EIGA Document 162	Code of Practice, Phosphine.
54	EIGA Document 163	Code of Practice, Arsine.
55	EIGA Document 169	Classification and labelling guide.
56	BCGA Code of Practice 4	Industrial gas manifolds and gas distribution pipework (excluding acetylene).
57	BCGA Code of Practice 23	Application of the Pressure Systems Safety Regulations 2000 to industrial and medical pressure systems installed at user premises.
58	BCGA Code of Practice 35	Filling ratios and developed pressures for liquefied and compressed gases.
59	BCGA Guidance Note 2	Guidance for the storage of gas cylinders in the workplace.
60	BCGA Guidance Note 3	Safe cylinder handling and the application of the manual handling operations regulations to gas cylinders.
61	BCGA Guidance Note 11	Reduced oxygen atmospheres. The management of risk associated with reduced oxygen atmospheres resulting from the use of gases in the workplace.
62	BCGA Guidance Note 27	Guidance for the carriage of gas cylinders on vehicles.
63	BCGA Technical Information Sheet 6	Cylinder identification. Colour coding and labelling requirements.
64	BCGA Technical Information Sheet 16	The storage of gas cylinders containing corrosive gas at users' premises.
65	BCGA Technical Information Sheet 17	Model risk assessment for manual handling activities in the industrial gas industry.

Document Number		Title
66	BCGA Technical Information Sheet 33	Good industry practice for the supply of cylinders containing corrosive gases.
67	BCGA Leaflet 6	Cylinders in fire.
68	Germany DIN 477	Gas cylinder valves for cylinder test pressures up to 300 bar.
69	USA, CGA G-13	Storage and handling of silane and silane mixtures.
70	USA, CGA V-1	Standard for compressed gas cylinder outlet and inlet connections.
71	SESHA	Environmental Code of Practice for the Microelectronics Industry.

Further information can be obtained from:

UK Legislation	www.legislation.gov.uk
Health and Safety Executive	www.hse.gov.uk
British Standards Institute (BSI)	www.bsigroup.co.uk
European Industrial Gases Association (EIGA)	www.eiga.eu
British Compressed Gases Association (BCGA)	www.bcga.co.uk
USA – Compressed Gas Association (CGA)	www.cganet.com
USA - American National Standards Institute (ANSI)	www.ansi.org
Germany - Deutshes Institut fűr Normung e.V. (DIN) - The German Institute for Standardization	www.din.de
Semiconductor Environmental Safety and Health Association (SESHA)	www.seshaonline.org
European Chemicals Agency (ECHA)	echa.europa.eu

BCGA OPINION ON THE USE OF GAS CABINETS

A European standard, BS EN 14470, Part 2 (42), 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 from a distance 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 (60) refers.

British Compressed Gases Association
www.bcga.co.uk