

NERC GUIDANCE SAFE STORAGE AND INSTALLATION OF GAS CYLINDERS

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BACKGROUND

Gas cylinders are widely used across NERC for activities ranging from providing special gases for laboratory equipment through engineering uses to field and medical applications. The main hazard from gas cylinders arises from the large amount of stored energy they contain due to the pressure of the compressed gas within them. If the pressurised gas is released in an uncontrolled manner this can cause considerable damage. Uncontrolled release and flying particles (including the cylinder itself) can occur from failure of the cylinder or its fittings and may arise if it is involved in a fire or it suffers damage in a collision. Gas cylinders also present a hazard from their contents which, even if not directly hazardous by nature of their flammable, toxic, corrosive or oxidising properties, can still cause an asphyxiant hazard by displacing oxygen. The inherent weight and size of cylinders may also present a physical hazard during transport and manual handling or if they topple.

The main causes of accidents from gas cylinders are:

- poor storage
- poor handling
- poor installation
- faulty equipment and / or design (eg faulty or incorrectly fitted/specified valves and regulators)
- poor examination and maintenance
- unplanned releases of gas
- hidden damage
- inadequate training and supervision.

This guidance is concerned with the storage and installation of gas cylinders. It is not primarily intended to cover their safety when in use or their standards of maintenance, transport or manual handling.

DEFINITION OF GAS CYLINDER

Gas cylinder is the term that is commonly used to describe the portable pressurised container used to store and transport gas but the correct legal definition of a gas cylinder is 'transportable pressure receptacle'. Another term used to describe a gas cylinder is 'gas bottle' but this term is generally frowned upon and is not used in this guidance.

Gas cylinders are generally made of carbon steel, stainless steel, aluminium or a composite (eg aluminium wrapped in carbon fibre for lightweight breathing air cylinders). They will contain either a gas at standard temperature and increased pressure (eg oxygen or nitrogen); a liquefied gas at standard temperature but

increased pressure (eg carbon dioxide) or a gas dissolved at standard temperature in a solvent (eg acetylene in acetone on an inert matrix). It is also possible to have a pressurised container with a gas that is liquefied at reduced temperature and increased pressure. Such gases are termed cryogenics (eg liquid helium) and the containers are commonly termed pressurised dewars. Cryogenics are covered by a separate NERC guidance document.

PERIODIC INSPECTION AND TESTING

Gas cylinders must be manufactured to an appropriate approved standard, of which there are a number according to type of cylinder and date of manufacture. Cylinders will have been examined after manufacture by a relevant inspection body to verify they have been manufactured correctly and conform to the appropriate design standard. The cylinder will be marked with a stamp or other indicator of the relevant inspection body. Cylinders and valves must be examined at specified regular intervals which are now covered by the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (CDG Regs) which implement the European 'ADR' regulations. However, there will be varying requirements / periods according to date of manufacture, type of construction and application and the Regs which applied. The inspection period is typically every ten years for industrial gases but can be shorter for special cylinders. The body of the cylinder will be permanently marked by the inspection body to show the date of the last periodic examination. The applicable BS EN standards which lay down inspection regimes are referred to at <http://www.hse.gov.uk/cdg/pressure.htm>.

Cylinders which have been kept in storage for long periods of time, eg exceeding five years, may be out of date for their inspection. This is one of the reasons why cylinders stocks need to be managed and cylinders should not be kept in storage for extended periods. Stocks should be rotated in storage to help ensure the oldest filled cylinders are used first. Cylinders that are no longer required should be returned to their supplier or otherwise safely disposed of. Another reason for not storing cylinders for extended periods is the cost as a rental charge may be in place on supplied cylinders.

MARKING / COLOUR CODING OF CYLINDERS and HAZARDS OF GASES

All gas cylinders must be clearly marked to show what they contain and the hazards associated with their contents. Unfortunately a variety of colour coding systems have been used in the past, which even varied from application to application (eg medical / non-medical) as well as from country to country. Cylinders of special gases and mixtures have often been sourced from overseas. The colours should now be standardised across Europe for medical and industrial gases, although some aspects are optional. The hazard warning colours that should be displayed across the shoulder on new cylinders (which may be in concentric bands or quarters if more than hazard is possessed) are, in ascending order of hazard:

Inert:	Bright green
Oxidising:	Light blue
Flammable:	Red
Toxic:	Yellow

The BCGA Technical Information Sheet TIS6 (based on the relevant BS EN Standard 1089-3 2011) gives the most recent colour coding system for European supplied cylinders. The following table gives a summary of the main categories of gases, their hazards and the warning sign colours. Some gases will exhibit more than one of these hazards eg carbon monoxide is both toxic and flammable.

Category	Hazard Diamond	Risk Phrase / Hazard	Comments
Oxidant	Green and Yellow	R8: Contact with combustible material may cause fire H271: May cause fire or explosion; strong oxidiser	Strongly support combustion but are not themselves flammable eg oxygen or nitrous oxide
Inert	Green	Asphyxiant in high concentrations	Do not generally react with other substances but can cause asphyxiation by displacement of oxygen eg argon, nitrogen.
Toxic	White	R23: Toxic by inhalation H331: Toxic if inhaled	Cause serious health effects on inhalation eg carbon monoxide, hydrogen sulphide
Very toxic	White	R26: Very toxic by inhalation H330: Fatal if inhaled	Cause very serious health effects on inhalation eg death eg phosphine, arsine
Flammable	Red	R12: Extremely flammable H224: Extremely flammable liquid or vapour	Will cause fire or cause explosion if mixed with oxygen or air and exposed to source of ignition eg hydrogen, acetylene
Pyrophoric	Red	R17: Spontaneously flammable in air H250: Catches fire spontaneously if exposed to air	If in contact with air can spontaneously ignite eg silane
Corrosive	White with dissolving hand symbol	R35: Causes severe burns H314: Causes severe burns and eye damage	Causes severe burns and damage to the eyes/ respiratory system if inhaled eg Cl ₂
Cryogenic	Green	Asphyxiant in high concentrations and may cause frostbite	Causes cold burns but can also displace air as liquid evaporates so causing asphyxiation due to lack of oxygen eg liquid nitrogen

STORAGE / INSTALLATION HIERARCHY

The size and number of gas cylinders in use or storage should be kept as small as practicable, having regard to the task(s) being performed and the need to maintain supply.

The hierarchy of storage options for gas cylinders is:

- In a safe place in the open air
- In specially designed, dedicated and well-ventilated gas cylinder storage/manifold rooms eg with two opposing walls that are 50% open to air
- Inside buildings in gas cylinder cabinets (see Appendix A).

An alternative approach is to dispense with gas cylinders altogether and use gas generators. These are commonly and successfully used to produce hydrogen for gas chromatography and nitrogen for mass spectrometry. Acetylene generators are also available.

Where none of the above is reasonably practicable, the gas cylinder should be secured in a safe place close to the point of use and removed to storage in one of the above locations as soon as possible after use.

It may not be possible or desirable for storage of cylinders of medical gases or breathing air to be stored in the open air but nevertheless the aim should be to minimise the number and size of cylinders stored within buildings, allowing adequate ventilation and protection from fire or other damage.

GENERAL STORAGE ISSUES

Cylinders should be inspected on receipt as placed in storage and on removal from storage prior to installation for signs of obvious damage. They should not be accepted or installed if there are obvious signs of damage (eg bent valves) but returned to the supplier.

Rotation of stores of gas cylinders to ensure that the first purchased gas cylinders are used before the last purchased should be encouraged. Gas cylinders should not be kept for extended periods. The size and number of the gas cylinders purchased should be matched to the anticipated usage.

Where gas cylinders containing toxic or flammable gases are brought into buildings, they must be removed to safe storage (see hierarchy of storage options above) when not in use. An exception can be made for 'lecture bottles' (small portable gas cylinders, typically of about 500ml volume used to supply gas for relatively small-scale laboratory experiments) provided they are inside fume cupboards or kept in a suitable mechanically extracted ventilated storage cupboard eg beneath a fume cupboard or a purpose built storage facility.

When stored outside, gas cylinders should be in a safe, dry, well-ventilated and secure location. The storage area should ideally be provided with simple protection

to protect the gas cylinders from the weather and direct sunlight (eg by a lightweight roof which has no pockets to trap escaped gas such as a ventilated apex) or in a cupboard with mesh or louvred doors. Storage areas and approaches, eg where unloading of cylinders occurs, should be as flat and level as possible to ease mechanical handling issues.

Gas cylinders must not be allowed to stand or lie in water.

Seals or covers should be kept in place on the valves of cylinders that are not in use to help prevent dirt or dust or other contaminants entering, which may affect gas quality, cause corrosion and prevent a good seal being obtained once connected to a supply. 'Empty' cylinders should always have their valve shut although gas cylinders should never be run to zero pressure and left totally empty.

The hazardous properties of the gas (including factors such as if it is unstable or susceptible to decomposition if subject to heat or shock as is acetylene) will also need to be considered when determining storage requirements / locations and may include enhanced requirements for ventilation, separation or keeping them cool.

When storage and use of gas cylinders inside a building is unavoidable, due consideration must be given to the:

- Separation/segregation from other activities and incompatible materials
- Provision of adequate ventilation
- Detection of leaks
- Protection from involvement in fire
- Materials handling aspects and safe access routes to bring gas cylinders into the building, avoiding the need to manually lift or accompany them in lifts
- Supporting/securing gas cylinders upright
- Maintenance of safe means of escape
- Possible need for explosion relief/prevention and for protected electrical equipment appropriate to any hazardous area classification when flammable gases are being stored / used.

All storage areas, laboratories, rooms or cabinets where gas cylinders are located should have warning signs displayed to indicate the presence of gas cylinders, hazards (eg flammable or toxic) posed by the gases together with any precautions that must be taken eg 'No naked lights/sources of ignition'. Gas cylinders should not be taken into or stored in unventilated rooms, which would include most cold-rooms.

Gas cylinders must be kept away from sources of heat eg direct sunlight that could cause an uncontrolled rise in the temperature of the contents leading to over-pressurisation and possible catastrophic failure of the gas cylinder. In rare cases it may be necessary warm gas cylinders intentionally, in which case stringent precautions should be taken to prevent the cylinder overheating.

Full, part-used and empty gas cylinders should be segregated and clearly labelled. Labels with tear-off sections that are removed as the cylinder progresses through its life-cycle are available to indicate the current status of the cylinder.

Gas cylinders should be secured upright and restrained at all times to prevent them falling over with consequent possible damage to persons, facilities, equipment or the gas cylinder and its fittings. They must also be protected from violent contact with other objects such as vehicles.

Gas cylinders should not be allowed to come into contact with electrical apparatus. A separation distance of at least 50mm between gas cylinders/gas pipework and electrical services should be ensured, except where electrical apparatus is purpose designed and installed for gas pipework applications eg auto-shut off, changeover systems and heaters on CO₂ supplies.

Cylinders of oxidant gases (eg oxygen and nitrous oxide) must be kept separated from cylinders of flammable gases or other flammable material, either by a distance of at least 3m or by a 30-minute fire-resisting wall. More detailed information on minimum separation distances is given in the BCGA Guidance Note GN2.

Single cylinders of oxygen and fuel gas may be kept together on a mobile trolley and used for oxy-fuel cutting/welding provided the trolley is returned to safe storage overnight. Guidance on the use of compressed gases in welding and similar operations is given in the HSE Booklet HSG 139.

Cylinders of LPG must be stored in approved stores. They should be returned to safe storage when not in use. It is permissible to store a small number (eg less than 5) of disposable cartridges/canisters of LPG in flammable solvent cupboards in laboratories where such items are in continuous use. LPG cylinders used to provide a local flammable gas supply where there is no plumbed natural gas should be kept outside a building and piped to the point(s) of use. Where this is not possible or is undesirable due to the distance of pipework involved, LPG cylinders may be kept in a ventilated gas cylinder storage cupboard within or close to the laboratory.

Gas cylinders will normally be fitted with a regulator when installed. Guidance on regulators is given in Appendix B.

References

1. 'Safe Use of gas Cylinders', HSE Guidance, version 1 Issued 2004
2. 'Guidance for the Storage of Gas Cylinders in the Workplace', GN2 (Revision 4), British Compressed Gases Association, 2011
3. 'The Safe Storage, Handling and Use of Special Gases in the Micro-Electronics and other Industries', CP18 (Revision 2), British Compressed Gases Association, 2005
4. 'The Safe Use of Compressed Gases in Welding, Flame Cutting and Allied Processes', HSG 139, HSE, revised 2002
5. 'Storage of full and empty LPG cylinders and Cartridges', Code of Practice No 7, UK Liquefied Petroleum Gas (UKLPG), 2004

6. 'Reduced Oxygen Atmospheres: The management of risk associated with reduced oxygen atmospheres resulting from use of gases in the workplace', Guidance Note GN11 (Revision 2), British Compressed Gases Association, 2007
7. 'The Safe Use of Oxy-Fuel Gas Equipment (Individual Portable or Mobile Cylinder Supply), CP 7 (Revision 5), British Compressed Gases Association, 2008
8. 'Safe Cylinder Handling and the Application of the Manual Handling Operations Regulations to Gas Cylinders', Guidance Note GN 3 (Revision 2), British Compressed Gases Association, 2010
9. 'Fire safety storage cabinets. Safety cabinets for pressurised gas cylinders', British Standard BS EN 14470-2:2006.
10. 'Safety of Pressure Systems: Pressure Systems Safety Regulations 2000', HSE Approved Code of Practice, L122, 2000.
11. Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (SI 2009 1348)
12. Pressure Systems Safety Regulations 2000 (SI 2000 No 128)
13. 'Cylinder Identification Colour Coding and Labelling Requirements', Technical Information Sheet TIS6, Revision 1, British Compressed Gases Association, 2005
14. BS EN 1089-3 2011: Identification of Contents of Industrial Gas Cylinders (*note: some cylinders may still display colours under the old BS 349 'Transportable Gas Cylinders, Gas Cylinder Identification (excluding LPG), Colour Coding' which has now been withdrawn*)

APPENDIX A: GAS CYLINDER STORAGE CABINETS

(note: much of the guidance in this appendix is based on advice contained in the BCGA publication 'The Safe Storage, Handling and Use of Special Gases in the Micro-Electronics and other Industries')

A gas cylinder storage cabinet is a purpose-built enclosure designed to provide safe containment of gas cylinders when they are installed within buildings. Their purpose is to provide protection, fire security, separation and ventilation to safely disperse any leaks etc. There is a standard, BS EN 14470-2:2006, that covers this application and cabinets which comply with it are very well built and of very high quality. However, the standard goes beyond the minimum required and cabinets built to comply with it are extremely expensive. It is possible to have cabinets purpose built by specialist suppliers which suit the particular needs of a situation.

Gas cylinders storage cabinets should:

- Be of a fire resisting construction offering at least 30 minutes protection against the passage of flame. As a minimum sheet steel of 2 mm nominal thickness will be suitable but cupboards with up to 2 hrs fire resistance are available.
- Be provided with forced extract ventilation whose discharge is to a safe location. For flammable gases the ducting will need to be fire resisting up to the point of any damper.
- Have their inlet and extract points fitted with automatic dampers to cut off air supply should the cabinet become exposed to a fire;
- Be labelled to give a indication of the nature of the hazards presented by their contents

The cabinet may contain spare cylinders and any auto-shut off or changeover devices but empty cylinders should be removed to an external storage area as soon as is practicable.

Gas cabinets should be dedicated to a specific gas or class of gas (eg flammable / inert / oxidising / toxic / corrosive).

If it is desired to store incompatible gases, eg flammable and oxidising, alongside each other they must be in different compartments with at least half hour fire protection between them to separate the incompatible cylinders.

The cabinet will need to be of sufficient strength and rigidity to provide effective support for the gas cylinders and associated equipment during normal use and cylinder handling operations. This should take account of any conditions or operations likely to be encountered, e.g. a toppling cylinder or local fire.

The cabinet door(s) shall be designed to give full opening to allow for changing of cylinders

For operations with extremely toxic or hazardous materials, a small access port may be located within the main door to allow for valve manipulation. The air flow across this port should be at least 0.5 mps to protect against escape of any leaking gas into the workroom.

If the threshold of the cupboard is not level with the floor, some form of access ramp eg a hinged drop down design located inside the cabinet door should be provided to allow heavy cylinders to be more easily manipulated into the cabinet

The cabinet should be provided with fittings, clamps or chains to securely locate and hold the gas cylinder once installed in the cabinet.

All joints which are regularly broken and re-made when installing cylinders should be positioned inside the cabinet as well as all associated valves, regulators and connectors.

Fittings should be adequately supported to avoid strain on joints and components during the connection and disconnection of containers.

There shall be a label and a hazard warning sign displayed on each cabinet identifying the gas within and any potential hazard(s) it presents (eg gas cylinder pictogram and wording).

Consideration shall be given to the monitoring of the air inside cabinets containing toxic gases and/or flammable gases to detect leaks.

The cabinet shall be provided with sufficient extraction ventilation with the aim of containing small leaks of gas and minimise their escape to the workroom. However, it is accepted no ventilation system would be able to deal with a major escape of gas. The extract volume maintain the potential concentration of leaking 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.

Electrical equipment should be excluded from within the cabinet as far as is practicable but if it is essential to locate it within the cupboard (eg auto-changeovers) it should meet any relevant standards eg if the gas is flammable, at least Zone 2 requirements.

It is best practice to have automatic gas/electrical shutdown of the cylinder supply in the event of ventilation failure or by interlocking to a gas detector within the cabinet or elsewhere.

The cabinet and all the equipment within the cabinet shall be electrically bonded to earth.

Gas cabinets may share the same extraction ducting providing reactions between incompatible gases are 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.

APPENDIX B: GAS CYLINDER REGULATORS

Introduction

A regulator is a device to control the pressure of gas supplied from a gas cylinder (or piped gas supply) and may also control flow. Regulators reduce the high pressures of the high pressure gas supply to lower pressures that can be safely used in an operating system. They may have one or more indicator dials, be fitted with flow indicators and flow control devices.

Regulators are precision instruments and must be handled and stored with care to avoid damage to their sensitive springs, diaphragms, valve seals, gauges etc. When disconnected and stored the pressure adjustment knob should be screwed fully out to minimise the tension on the springs and diaphragms.

Regulators include a relief device which prevents excessive pressure from developing or releases pressure should a component such as the diaphragm fail. This will normally be via a safety-back construction which relieves from the rear of the regulator with the light-metal safety back blowing off. However, this does not mean that it can never fail via the front. This is why the operator should always stand away and to one side when operating a regulator

General Requirements for Regulators

1. A gas cylinder regulator may form part of a pressure system under the Pressure Systems Safety Regulations 2000 (PSSR) and so be subject to a written scheme of maintenance containing requirements as to inspection and maintenance.
2. Unless specifically agreed by the competent person under the PSSR, regulators should be replaced, or sent for servicing/reconditioning, after five years in use or, if used with corrosive gases, more frequently - possibly every two years.
3. The regulator should have markings which indicate the pressures up to which it can safely operate. A regulator should never be used to control pressure from a cylinder containing gas that is above its design pressure. Ideally they should also be marked to indicate the gas (or class of gas) for which they are designed to be used.
4. All regulators should be labelled with a unique identifier and subject to regular inspection with a central log of all regulators on site kept to allow compliance with PSSR.
5. Where a regulator is not in regular or constant use, it is best practice to keep a central stock of regulators from which users draw and return as needed. This allows better control, compliance with inspection regimes and helps ensure a stock of the correct regulator for each application is available.

6. Regulators must be in good condition and only be used for the type of gas for which they are designed, being constructed of a suitable material that is compatible with the gas being used and purity required.
7. Care with corrosive gas applications is required. Regulators fitted with a purging connection are available which allow them be purged with an inert gas after use.
8. Do not modify regulators, remove their inlet connections as fitted by the manufacturer or connect adaptors unless this has been approved and undertaken by a competent person.
9. Damaged regulators must be removed from use and sent for repair by competent persons.
10. Where regulators supply gas to equipment or apparatus containing liquid and the gas is introduced directly into the liquid, the risk of suck-back must be protected against. This can be by means of non-return valves in the supply line or catch pots created by using empty in-line intermediate containers.
11. Liquid supply, liquefied or dissolved gases should be controlled in accordance with supplier's instructions.
12. Regulators for flammable gas cylinders need to be installed in conjunction with a flashback arrester (on both fuel and oxygen supply for oxy-acetylene or oxy-propane equipment with non-return valves close to the welding torch).