UNIVERSITY OF BIRMINGHAM

COMPRESSED GAS SAFETY

HEALTH AND SAFETY UNIT

CGS 24.8.10

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COMPRESSED GAS SAFETY

Introduction

Compressed gas has a variety of uses from breathing (as in diving), through dispensing of beverages (as in draught beer), fuel for vehicles, laboratory experiments to welding.

Compressed gas cylinders (and disposable cartridges) are a convenient way to transport and store gases under pressure - a lot of gas is contained in a small volume. Compressed gas containers are therefore pressure vessels. Mishandling or misuse or overheating (especially if caught in a building fire) could cause the full gas pressure to be suddenly released. In such circumstances, gas containers can become very dangerous projectiles. Some gases are harmful to health others are serious fire risks. The larger cylinders are heavy and awkward to handle. Accidents involving gas cylinders can cause serious injury or even death.

The University's Policy and requirements for compressed gas safety are set out in *Compressed Gas* (UHSP/20/CG/03)

Compressed gas is supplied in refillable cylinders (smaller versions for LPG may be called bottles) usually owned by the gas supplier or in disposable cartridges.

The quality and condition of gas cylinders is controlled by statutory requirements and duties imposed on the owners. These duties are onerous and therefore the use of privately owned cylinders should only be considered in exceptional circumstances.

Compressed Gas requires special equipment for its use, some of which may require statutory testing.

PRINCIPAL HAZARDS

High Pressure

Compressed gas cylinders are pressure vessels. If, as a result of mishandling or misuse, the full gas pressure were to be suddenly released, they can become very dangerous projectiles, behaving just as a toy balloon does if it is let go before the end is tied up.

Hazardous Substances

Many compressed gases possess one or more of the chemical hazards. (i.e., may be toxic, corrosive, flammable, oxidizing or explosive.)

Asphyxiation

There is the additional hazard of the displacement of atmospheric oxygen and the risk of asphyxiation if excessive amounts of gas are allowed to escape into the workplace atmosphere.

Cylinder Weight and Size

The larger cylinders weigh around 70 kg and are easily toppled over. Cylinders are awkward objects to handle.

Type of Gas

The hazards presented by compressed gases are also dependent on the form in which the gas is present in the cylinder: liquefied, gaseous, or dissolved compressed gas.

TYPES OF COMPRESSED GAS

Liquefied Compressed Gas

Many gases turn to liquid when compressed. Cylinders of liquefied compressed gases under pressure contain both the liquid and the gas. Cylinders of this type of gas must be kept vertical so that only the gas may pass out through the valve.

The pressure of gas in the cylinder will remain constant until nearly all the liquid has turned to gas and the cylinder is near empty. Pressure varies from gas to gas according to the vapour pressure of the substance and, as can be seen below, is relatively low.

Examples of this type of gas are:

ammonia	114 psig	7.9 bar(g)	0.79 MPa
butane	16 psig	1.1 bar(g)	0.11 MPa
carbon dioxide	830 psig	57.2 bar(g)	5.7 MPa
chlorine	85 psig	5.9 bar(g)	0.59 MPa
nitrous oxide	745 psig	51.4 bar(g)	5.1 MPa
propane	109 psig	7.5 bar(g)	0.75 MPa

(Butane and propane are examples of LPG - liquefied petroleum gas)

However, pressure increases with temperature and for this type of gas will do so rapidly because of the very high liquid-to-gas expansion ratio. Cylinders for these low pressure gases are of less substantial construction and therefore at more risk of bursting if over-pressurised. At higher temperatures the cylinder will also be subject to the hydraulic pressure of expanded liquid filling the cylinder. Gas cylinders should not normally be subjected to an air temperature above 40°C.

LPG is often used as a fuel in portable equipment using an attached disposable cartridges. Even greater care is needed to protect flimsy disposable cartridges from physical damage or overheating.

For some gases the cylinder is fitted with a safety valve or a bursting disc.

Some applications require the liquid rather than the gas. Special cylinders with fittings for liquid withdrawal are available for this purpose.

Gaseous Compressed Gas

Certain gases cannot be liquefied by the action of pressure alone, for this reason they are known as permanent gases. These gases may be compressed to 3500-4500 psi (230-300 bar or 24-31 MPa); the cylinder pressure gradually falls as gas is drawn off.

Examples are:

- argon
- carbon monoxide
- helium
- hydrogen
- nitrogen
- oxygen

Dissolved Compressed Gas

Acetylene is a very unstable gas which is liable to explode when compressed. At pressures above 9 psi (0.62 Bar/0.062.1kPa) it is regarded as an explosive and its use is controlled by Explosives Act regulations. The instability of compressed acetylene is avoided by dissolving it under pressure (typically 275 psi/19 bar/ 1.9 MPa) in acetone which can hold up to 25 times its own volume of acetylene. Acetylene cylinders are 1/3 filled with acetone and must be used in the vertical position in order to avoid loss of acetone. The cylinders are also filled with a porous mass which is intended to inhibit the spread of fire.

Acetylene is well known for its ability to continue to burn in the absence of air. That is, if a fire travels back into an acetylene cylinder the gas will continue to decompose and heat up. This is likely to cause the cylinder to burst propelling metal fragments over a wide area. Undecomposed hot gas will ignite explosively on contact with the air to create a fireball up to 25 metres or more in diameter.

Older acetylene cylinders may be fitted with a bursting disc or fusible plugs.

CYLINDER IDENTIFICATION

Various regulations apply to the labelling of gas cylinders to ensure that in use and when being transported the risks to health and safety and the contents of a cylinder are identified. There is also an European Standard Colour Coding (BS EN 1089-3) which provides an additional means of identifying the hazard, and in certain cases the contents, when a label cannot easily be read (e.g. when the gas cylinder is viewed from a distance). The identifying colours are applied to cylinder shoulders.

Single Hazard (in descending order)		Colour
Toxic and/or corrosive	 or 	YELLOW
Flammable		RED
Oxidizing		LIGHT BLUE
Inert		BRIGHT GREEN

Combinations of colours are used when a gas displays two hazards or for gas mixtures.
Further details of the colour coding for individual gases and the requirements of BS EN 1089-3 are in the Appendix to this manual.

As a further precaution, the valve outlets on cylinders containing flammable gases have left-hand threads and those on cylinders containing non-flammable gases have right-hand threads. This feature is intended to prevent the accidental interchange of oxygen and fuel gases and their equipment.

FURTHER COMPRESSED GAS HAZARDS

Cylinder Overheating

This will result in an increase in internal pressure and, in extreme cases, could cause the cylinder wall to weaken and bulge or fail (burst with fragments popelled over a wide area). Hot flammable gases are likely to ignite explosively on contact with the air. Such failure of LPG cylinders may result in a BLEVE (boiling liquid expanding vapour explosion) creating a huge fireball. Propane cylinders, weighing 70kg, have been known to be propelled up to 200 metres in such circumstances.

Overheating may be caused by:

- flame from an oxy-torch;
- an arc from an electrical welding tool too close to the cylinder wall;
- contact with welding and cutting sparks, spillages of molten metal;
- being placed too close to a source of heat, especially a furnace.

Flashbacks

A flashback is the passage of flame back through a burner or blowpipe into hose or pipework, and even the regulator. A flashback which passes back into an acetylene cylinder can cause heating and explosive decomposition in the absence of air.

Flashbacks can be caused by:

- failure to follow recommended procedures, e.g., higher pressure gas in one hose can feed back up the other hose which is at a lower pressure;
- nozzle or burner blockage;
- faulty equipment.

Gas Escape or Leaks

Gas escaping from a cylinder valve or from an unlit burner or blowpipe or leaking from faulty or incorrectly assembled equipment can collect in confined spaces and cause either a fire or a health hazard. For example:

- a build up of oxygen will cause fires to ignite and to proceed much more readily – the safe limit is 23%v/v in air, compared with normal concentration of 20.9%;
- leakage of gases other than oxygen will reduce the proportion of oxygen present and increase the risk of asphyxiation.

Equipment Contamination

Contamination can take several forms:

- grit, dirt, metal filings;
- oil and grease;
- water;
- air;

and the incompatibility can be specific to the gas.

Grit, dirt, etc.

Grit and dirt in valve sockets, etc., may produce poor seals and cause leaks, and may even be incompatible with the gas. All debris, including specks of metal, are liable to violent ignition in a high pressure flow of oxygen.

Cylinder valves, with the exception of hydrogen, can be cleaned by snifting some gas - momentarily opening and closing the valve.

NB When snifting:

- there should be no sources of ignition in the vicinity;
- the area should be well ventilated;
- do not allow the gas stream to contact the face or hands;
- do not snift hydrogen (if there are signs of dirt blow it out with clean nitrogen).

Water

Water or moisture contamination must be avoided with corrosive gases such as hydrogen chloride. Equipment designed for the purpose must be employed and the whole system purged before use with dry inert gas. The system should also be purged after use and before dismantling.

Some gases, e.g., LPG, may have a small water content, sufficient to significantly corrode flimsy disposable cartridges over a period of time. For this reason, disposable cartridges should be date stamped and periodically examined for signs of corrosion. Excessive stocks should not be held so that they can be used before significant corrosion can occur and to avoid the need for disposal of unused cartridges.

Air

Some gases, e.g. silane, are spontaneously flammable in air. Systems must be purged as above.

Oil and grease

Oil and grease contamination is potentially very dangerous.

NB the lubrication of valves and fittings is unnecessary.

The contamination of oxygen equipment is especially dangerous. Greasy hands, gloves and rags should be kept well away from any part of a cylinder and fittings. Equipment should be thoroughly cleaned and degreased before assembly.

High pressure oxygen reacts violently, even explosively, on contact with oils, greases, other organic matter, metal splinters, etc.

COMPRESSED GAS EQUIPMENT

The correct choice of equipment is important. Not only in terms of purpose and function but also compatibility with the pressure involved and the properties of the gas. Some equipment is designed for direct metal to metal connection and further seals/sealant should not be used. Where seals, gaskets etc. are needed these must be compatible with the gas.

The Cylinder Outlet Valve

The valve fitting on a gas cylinder is always opened anti-clockwise and closed clockwise.

This valve should be opened slowly, using the correct spindle key, and turned back at least 1/2 a turn before the backstop to show that the valve is open. It should not normally be necessary to open a valve much more than one turn.

NB The cylinder outlet valve does not regulate gas pressure and it also should not be used to control the rate of flow of gas.

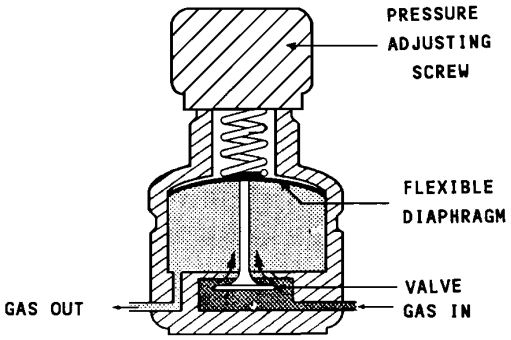
Liquid Withdrawal

Where the work requires a supply of the liquid component of a liquefied compressed gas, special cylinders are available and should be used for this purpose. Equally, the drawing off of gas from a liquid withdrawal cylinder should not be attempted.

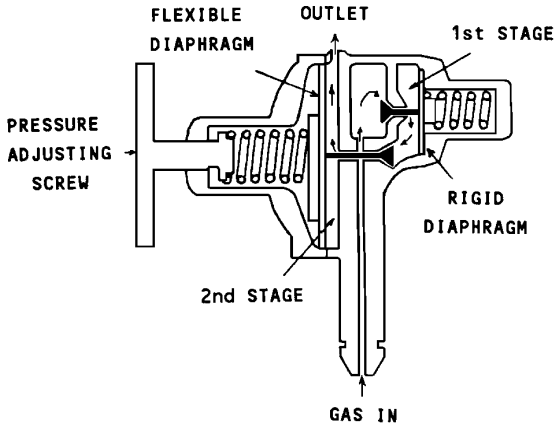
Pressure Regulators

For most uses the pressure of gas in a cylinder is too high. Gas cylinders and cylinder outlet valves are designed to supply gas through a special pressure regulator which can reduce cylinder pressure to the much lower working pressure. A pressure regulator does not control the rate of flow of gas - a separate flow control valve is required to control gas flow.

There are two principal types of pressure regulator. In a single stage regulator the pressure reduction is performed in one step. For high pressure gases single stage regulation gives only a coarse control of pressure and further re-adjustment is required as the pressure in the cylinder falls.



Single Stage Regulator



Multi-stage Regulator

The two stage regulation of a multistage regulator allows a finer adjustment and also a stable outlet pressure with no need of further adjustment.

NB Since the properties and cylinder pressure vary from gas to gas many pressure regulators are not interchangeable from one gas to another.

Except where several cylinders are manifolded together, a pressure regulator is usually screwed directly into the cylinder outlet valve.

Different specifications of pressure regulator are available for different types of gas and for different fixed or variable outlet pressures. Gas pressure regulators are manufactured to cope with a maximum gas cylinder pressure beyond which they may fail, possibly with very damaging consequences. A good quality pressure regulator manufactured to a recognised standard will be marked with the maximum inlet pressure. For example, a gas pressure regulator to BS EN ISO 2503:1998 is suitable for gas cylinder pressures up to 300 bar (but not including liquefied or dissolved gases).

Older regulators may not be able to withstand current cylinder pressures. In 1965, the filling pressure of common gases including hydrogen, argon, helium, oxygen and nitrogen was 137 bar. For various reasons, the filling pressure has been increased over the years (to 170 bar in 1975, to 200 bar in 1977 to 230 bar in 1987, but at later dates for some gases) and for some gases is liable to increase further to 300 bar over the next few years. Oxygen and hydrogen are very dangerous gases and are liable to ignite on release at high pressure from a failed regulator. Cylinders filled to 230 bar are marked with a green band.

Setting Up A Pressure Regulator

1. Close any valve beyond the outlet of the regulator.
2. Turn the pressure adjusting screw anticlockwise until spring pressure is released.
3. Turn the cylinder valve anticlockwise until the contents gauge registers cylinder pressure (leave at least 1/2 a turn before backstop).
4. Slowly turn the pressure adjusting screw clockwise until the outlet gauge registers the required working pressure.
5. Test joints with leak detection fluid (such as water containing ½% washing-up liquid).
6. Open the outlet valve and make final adjustment to pressure.

Closing Down a pressure regulator

1. Close the outlet valve.
2. Turn the pressure adjusting screw anticlockwise until spring pressure is released.
3. Turn the cylinder valve clockwise to close.
4. Disconnect equipment from the outlet and open the outlet valve.
5. Screw in the pressure adjusting screw to release residual gas from the regulator, then unscrew as in 2.

Flow Control Valves

A flow control valve should be fitted downstream of the regulator to allow fine adjustment of the rate of gas flow.

Non-return Valves

A non-return valve is designed to prevent a reverse flow of gas. Non-return valves are particularly important where different gases are piped to a common junction, as in blowpipes, burners, etc.

Some equipment is supplied fitted with non-return valves.

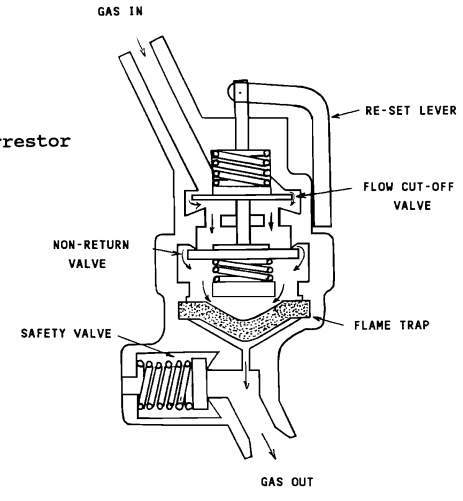
If mains gas is used mixed with compressed air or oxygen the law requires an approved non-return valve in the mains gas supply.

Flashback Arrestors

A flashback arrestor is designed to stop flame travelling back into a gas cylinder. Some flashback arrestors are also fitted with a cut-off valve which automatically shuts off the gas flow if there is a reverse flow and/or a flashback.

The correct flashback arrestor must be chosen to match the gas and the maximum rate of gas flow.

Flashback Arrestor



Metal Pipework

Pipework and associated fittings must be made from a material suited to the properties of the gas and to avoid adverse interactions (E.g., acetylene forms explosive acetylides with copper, silver and brass). Pipework must also be capable of withstanding the maximum forseeable pressure in a system.

It is not necessary to use tape or jointing compounds if the correct fittings are used, and these are in good condition.

Metal pipework carrying flammable gases should be continuous; if joints are unavoidable these should be hard soldered or welded.

Flexible Hose and Tubing

Flexible hose or tubing should never be used as a substitute for permanent metal pipework.

The properties of some gases can cause damage to hose and tubing materials. For example, hydrocarbon gases such as natural gas (mains gas in the UK) and propane can seep through natural rubber.

It is also important that hose and tubing is capable of withstanding the conditions of a work procedure, such as resistance to heat or flame, resistance to kinking, resistance to physical abrasion, etc. And, not least, be capable of withstanding the maximum forseeable gas pressure from the particular application.

Where possible, hose and tubing should be selected from the British Standard Specification (see references) which most closely matches the work or application, taking into account:

- type of gas;
- maximum operating pressure;
- operating temperature range;
- potential for exposure to heat or flame;
- physical wear and tear. (See appendix)

The BS colour coding for hoses should be followed.

Acetylene and other fuel gases (not LPG)	red
Oxygen	blue
Non-combustible gases	black
LPG	orange

Hose lengths should not be longer than is necessary. Hose should never be used wrapped round a cylinder or regulator.

Hose and tubing must be securely clamped to equipment using either the manufacturer's fittings or suitable clips. Twisted wire and re-useable worm screw fittings are not suitable for this purpose.

THE SAFE USE OF COMPRESSED GASES

Information, Instruction and Training

1. DO NOT carry out maintenance, repair or alterations to compressed gas equipment unless you have been adequately trained and are competent and authorised to carry out the work.
2. Ensure you have been given information, instruction and training sufficient to enable you to understand the risks associated with gas cylinders and cartridges and their contents and to be able to work safely.
3. Know and understand the manufacturer's recommendations and instructions before using compressed gas equipment.
4. Never remove or obscure original labelling on a gas cylinder, and always check the identity of a gas before using it.

Inspection, Testing and Service (for details see the Appendix)

5. Before each period of work, carry out an external visual inspection of the gas cylinder or cartridge, and any attachments (e.g., valves, flashback arrestors, regulators, hoses), to confirm suitability for the work activity and that they are not damaged.
6. All joints, from the cylinder/cartridge through the gas equipment, must be checked regularly for leaks at the working pressure.
7. DO NOT USE compressed gas equipment if the annual maintenance inspection and functional checks are overdue.

Equipment

8. Use a suitable pressure regulator, fitted to the cylinder, to reduce the pressure of gas down to a range close to the maximum working pressure and as low a level as is practicable.
9. Ensure the gas regulator and pipework/hose are suited to the type of gas and the pressures involved and also seals, gaskets, etc, if any, are compatible with the gas.
10. Wherever possible connection to appliances must be via rigid pipework which terminates at a gas tap. Flexible connections must be of hose to an appropriate standard.
11. Pipework and flexible hose must be protected against accidental damage and properly supported.
12. A suitable flashback arrestor and cut-off valve must be fitted at the regulator outlet on:
    - an acetylene cylinder;
    - a flammable gas cylinder where there is an ignition source;
    - on both the oxygen and flammable gas cylinders where the gases are combined.
13. Non-return valves must be fitted in the gas supply lines at the point of connection of the equipment covered by paragraph 11 above.
14. Use only the recommended cylinder valve key (spanner) to attach fittings to a cylinder. Never increase the leverage on a key or use a longer spanner.

Working Practices

15. DO NOT USE acetylene at pressures above 9psig (0.62 Bar/0.062MPa).
16. Keep the cylinder valve closed at all times when the gas is not in use.
17. Return the regulator pressure adjusting screw to the zero position (fully anticlockwise) when the regulator is not in use.
18. Protect cylinders from fire or overheating by keeping well clear of furnaces, etc., flames and other sources of ignition and combustible materials. Ambient air temperature should not exceed 40°C.
19. Use personal protective equipment to protect eyes, hands, feet, as appropriate, when working with gas cylinders
20. Always secure a gas cylinders in a clamp attached to a wall or other rigid structure or in a stable stand.
21. Never subject a gas cylinder to abnormal shocks.
22. Use gas cylinders in a vertical position, unless specifically designed to be used otherwise.
23. Purge the system before use where the gas is incompatible with air or water.
24. Ensure oxygen equipment is kept free of oil and grease.
25. Always use toxic gases in a fume cupboard.
26. Do not allow toxic or flammable gases to escape into the atmosphere.
27. Take care not to allow too much inert gas to displace oxygen in the atmosphere.
28. Do not allow the atmosphere to become enriched with oxygen.

Transport

29. Use a cylinder trolley when cylinders are moved from place to place.
30. When moving gas cylinders between buildings or transporting by road follow the requirements of Schedule 6 of Hazardous Substances Policy.

    NB A private motor car or other vehicle that does not have a gas-tight partition separating the driver from the load is unlikely to be suitable for transport by road.

Storage

31. Do not exceed the permitted number of cylinders in a workroom (see University Hazardous Substances Policy, UHSP/15/HS/00 Schedule 5).
32. DO NOT store gas cylinders and cartridges that are not in use within laboratories or workrooms.
33. Return un-used and "empty" gas cylinders to the external store.

Disposable Cartridges and Portable Equipment

34. Carry out the connection and disconnection of LPG containers from appliances in a well ventilated place, preferably in the open air, away from possible sources of ignition and only when the appliance is cold.
35. DO NOT DISCARD full nor empty LPG cartridges in internal waste bins. Full cartridges must be emptied in a safe place before disposal.
36. DO NOT USE LPG cartridges beyond the "use by" or "disposal date".

EMERGENCY ACTION

Acetylene Cylinder Overheated

1. Shut cylinder valve.
   NB If cylinder is too hot to touch continuously go to 6.
2. Detach pressure regulator or other fitting.
3. Take cylinder out of doors and immerse or drench in cold water until cylinder is cool (i.e., until it remains wet when water treatment is stopped. This may take several hours.)
4. Meanwhile, contact the suppliers for further advice.
5. Thoroughly ventilate the area.
6. If cylinder is too hot to touch continuously, do not move it but drench with cold water.
7. Call the fire service and evacuate the area.

Leaking Non-toxic Gas Cylinders, minor leaks not on fire

If an acetylene valve shows a minor leak and it cannot be stopped by closing the valve or by tightening the gland nut, , move the cylinder outside to a safe area and contact the supplier. Take the same action if a safety device shows a small leak.

1. If gas is flammable or oxidising, eliminate all sources of ignition
2. If possible stop leak by shutting off cylinder valve or by tightening the gland nut.
3. If not possible to stop leak, remove to a safe outdoor location and contact supplier.
4. Keep liquefied compressed gases upright and well clear of drains and pits.
5. Ventilate site of leak.

Leaking cylinder on fire:

1. If gas from a cylinder valve is alight, IF IT IS SAFE TO DO SO, either turn off the valve promptly to extinguish the flame or extinguish the flame and then turn off the valve. Take care as there is little radiant heat from a hydrogen fire to warn of the flame.
2. If the flame from the leak cannot be extinguished by turning off the valve, fire fighting should only be carried out by trained personnel or Fire Service.
3. Call Fire Service.
4. Where possible and IF IT IS SAFE TO DO SO the cylinder and adjacent cylinders should be cooled by spraying with copious quantities of water.
5. IF THE FLAME FROM A BURNING LEAK IMPINGES ON A CYLINDER AND THIS CANNOT BE STOPPED THE AREA MUST BE EVACUATED IMMEDIATELY.

Other Overheated Gas Cylinders

1. Take action to eliminate the fire so as to prevent the cylinder from bursting through the damage caused by excessive heating.

2. Where possible and IF IT IS SAFE TO DO SO the cylinder and adjacent cylinders should be cooled by spraying with copious quantities of water.
3. Where a fire nearby is threatening LPG containers, they should be moved to a safe place PROVIDED THIS CAN BE DONE SAFELY. Where the cylinders cannot be moved they should be cooled by spraying with copious quantities of water.

Frozen Regulators or Valves

Thaw with hot water, never by flame. This condition is a sign of excessive flow rates. Seek advice from the gas supplier.

NO ATTEMPT MUST BE MADE TO DISMANTLE OR REPAIR DEFECTIVE CYLINDER VALVES

Flashback or Sudden Extinguishing of Flame

1. Close both blowpipe valves, oxygen first.
2. Close both cylinder valves.
3. Unscrew pressure adjusting screw on both regulators.
4. If blowpipe is overheated plunge it into cold water.
5. Check that the nozzle is not damaged, and check it is tight.
6. If all appears well, carry through the start up procedure as recommended by the equipment supplier.

If the flashback recurs immediately, the blowpipe/nozzle is likely to be faulty.

Frosted cylinders

This is due to excessive draw-off rate and can be overcome by manifolding cylinders - do not heat the cylinders.

APPENDIX
INSPECTION AND TESTING

For details of annual checks see University Policy *Compressed Gas* (UHSP/20/CG/03).

Each time the equipment is used

Gas cylinders and cartridges

- external, visual inspection of condition of cylinder/cartridge and valve, looking for signs of damage such as bulges, dents, scorch marks, corrosion, contamination, severe grinding marks, crossed thread, etc;
- check label to confirm
  - correct gas/specification; and
  - whether any "use by" or similar date has been exceeded.

Pressure Regulators

- external, visual inspection for:
  - signs of damage or contamination; and
  - condition of threads and sealing surfaces;
- check label and specification to confirm suitability for:
  - gas;
  - maximum cylinder pressure; and
  - working pressure.

Flashback Arrestors

- external, visual inspection for:
  - signs of damage or contamination; and
  - condition of threads and sealing surfaces;
- check label and specification to confirm suitability for:
  - gas;
  - pressure and flow rate.

Hose Assemblies (including non-return valves)

- external, visual inspection of all components for:
  - signs of damage or contamination;
  - condition of hose cover, whether kinked or twisted;
  - condition of threads and sealing surfaces;
- check label and specification to confirm suitability for:
  - gas;
  - pressure and flow rate.

All Equipment

Leak test all joints at working pressure.

Further Guidance

British Compressed Gases Association

GN2 (rev 3)	Safe Practice for the Storage of Transportable Gas Cylinders for Industrial Use	2005
GN7 (rev 1)	The Safe Use of Individual Portable or Mobile Cylinder Gas Supply Equipment:	2004
L1 (Rev. 3)	Guidance for Carriage of Gas Cylinders on Vehicles	2010
L6 (issue 3)	Cylinders in Fires [http://www.bcga.co.uk/publications/L6.pdf]	2008
CP7 (rev 5)	The Safe Use of Oxy-Fuel Gas Equipment (Individual Portable or Mobile Cylinder Supply)	2008
CP 18 (rev 2)	The Safe Storage, Handling and Use of Special Gases in the Microelectronics Industry	2005
CP31	Safe Storage and Use of Cylinders in Mobile Workshops and Service Vehicles	2010
CP33	The Bulk Storage of Gaseous Hydrogen at Users' Premises	2005
TIS8	Information for Customers Collecting Gas Cylinders (Flammable, Inert and Oxidising Gases) [http://www.bcga.co.uk/publications/TIS08.pdf]	2005
TIS12	Handle Gas Cylinders Safely [http://www.bcga.co.uk/publications/TIS12.pdf]	2005

Health and Safety Executive

	Safe Use of Gas Cylinders [http://www.hse.gov.uk/cdg/pdf/safusgc.pdf]	2004
HSE8(rev.2)	Take care with oxygen : fire and explosion hazards in the use of oxygen. [http://www.hse.gov.uk/pubns/hse8.pdf]	2008
INDG261	Pressure systems: Safety and you [http://www.hse.gov.uk/pubns/indg261.pdf]	2001
INDG297	Safety in Gas Welding, Cutting and Similar Processes [http://www.hse.gov.uk/pubns/indg297.pdf]	2000
INDG327	Take care with acetylene [http://www.hse.gov.uk/pubns/indg327.pdf]	2000
HSG139	The safe use of compressed gases in welding, cutting and allied processes [http://www.hse.gov.uk/pubns/priced/hsg139.pdf]	1997
CHIS 5	Small-scale use of LPG in cylinders [http://www.hse.gov.uk/pubns/chis5.pdf]	1999

Equipment Standards for Compressed Gases

BS EN 1089-3: Transportable Gas Cylinders- Cylinder identification - Part 3: Colour coding

This Standard applies to industrial and medical gas cylinders. This Standard **does not apply to LPG or to fire extinguishers**.

Cylinder colours refer to the contents of cylinders and are used to complement cylinder labels. The label is the primary method of indicating cylinder contents. However, when it is not possible to read labels, cylinder colours are an important additional method of contents identification.

Colour coding is used primarily to identify the hazard associated with the contents of a cylinder. The hazard is that indicated by the risk diamond required by transport regulations. The purpose of colour coding is to complement cylinder labels.

In addition, certain gases are assigned a specific colour and therefore in these cases the colour does identify the contents.

The identifying colours are applied to cylinder shoulders, in a format specified in the Standard.

Hazard Colours

When only one hazard applies to a single substance or to a gas mixture the following colours are specified in descending order of hazard.

Single Hazard (in descending order)	Colour
Toxic and/or corrosive	YELLOW
Flammable	RED
Oxidizing	LIGHT BLUE
Inert	BRIGHT GREEN
Note BRIGHT GREEN is not to be used for air for inhalation, see below.	

Where more than one hazard applies to a single substance or to a gas mixture the following colour coding is specified.

Multiple Hazards	Colours		
Toxic (and/or corrosive) and flammable	YELLOW	plus	RED
Toxic (and/or corrosive) and Oxidizing	YELLOW	plus	LIGHT BLUE

Specific Gas Colours

Flammable Gases	Colour
Acetylene	MAROON
Oxidising Gases	
Oxygen	WHITE
Nitrous oxide	BLUE

Inert Gases for Medical Use	Additional Colours
Argon	DARK GREEN
Nitrogen	BLACK
Carbon Dioxide	GREY
Helium	BROWN
Note 1 these colours may also be applied for non-medical use. 2 combinations of these colours may be used for inert gas mixtures	

Gas Mixtures Used for Inhalation (e.g for BA)			
Air or synthetic air	WHITE	plus	BLACK
Helium/oxygen	WHITE	plus	BROWN
Oxygen/carbon dioxide	WHITE	plus	GREY
Oxygen/nitrous oxide	WHITE	plus	BLUE
Note These colours are not for industrial use			

Indication of Compliance with this Standard

All cylinders colour-coded in accordance with this Standard will also be marked twice with the letter **"N"** on the shoulder of the cylinder.

Flexible Hose and Tubing

Flexible hose and tubing must be suitable for the work. There are various British Standards Specifications for construction and performance requirements, covering different applications, but none specifically for laboratory equipment. Where possible flexible hose and tubing should be selected to the British Standard which most closely matches the work or application, taking into account:

- type of gas;
- maximum operating pressure;
- operating temperature range;
- potential for exposure to heat or flame;
- physical wear and tear.

BS EN 559:2003 Gas Welding Equipment. Rubber hoses for Welding, Cutting and Allied Processes

BS 3212:1991 Specification for flexible rubber tubing, rubber hose and rubber hose assemblies for use in LPG vapour phase and LPG/air installations

BS EN 1762:2003 Rubber hoses and hose assemblies for liquefied petroleum gas, LPG (liquid or gaseous phase), and natural gas up to 25 bar (2,5 MPa). Specification

BS EN 1327:1996 Gas welding equipment. Thermoplastic hoses for welding and allied processes

BS EN 1256:2006 Gas welding equipment. Specification for hose assemblies for equipment for welding, cutting and allied processes. Replaces BS EN 1256:1996

BS EN ISO 5359:2008 Low-pressure hose assemblies for use with medical gases. Replaces BS EN 739:1998

BS 8789:1994 Rubber hoses and hose assemblies for liquefied petroleum gas in motor vehicles

BS EN ISO 2398:2008 Rubber hoses, textile-reinforced for compressed air. Specification
Replaces BS EN ISO 2398:1997 BS 5118

Pressure Regulators

BS EN 12864:2001 Low-pressure, non adjustable regulators having a maximum outlet pressure of less than or equal to 200 mbar, with a capacity of less than or equal to 4kg/h, and their associated safety devices for butane, propane or their mixtures. Partially replaces BS 3016:1989

BS EN 13785:2005 Regulators with a capacity of up to and including 100 kg/h, having a maximum nominal outlet pressure of up to and including 4 bar, other than those covered by EN 12864 and their associated safety devices for butane, propane or their mixtures. Partially replaces BS 3016:1989

BS EN 13786:2004+A1:2008 Automatic change-over valves having a maximum outlet pressure of up to and including 4 bar with a capacity of up to and including 100 kg/h, and their associated safety devices for butane, propane or their mixtures. Partially replaces BS 3016:1989

BS EN ISO 2503:2009 Gas welding equipment. Pressure regulators and pressure regulators with flow-metering devices for gas cylinders used in welding, cutting and allied processes up to 300 bar (30 MPa)
Replaces BS EN ISO 2503:1998, BS 7650, BS 5741, BS EN 585

BS EN ISO 10524-2:2006 Pressure regulators for use with medical gases. Manifold and line pressure regulators

BS EN ISO 10524-3:2006 Pressure regulators for use with medical gases. Pressure regulators integrated with cylinder valves

BS EN ISO 7291:2001 Gas welding equipment. Pressure regulators for manifold systems used in welding, cutting and allied processes up to 300 bar

Safety Devices

BS EN 730-1:2002 Gas welding equipment. Safety devices. Incorporating a flame (flashback) arrestor

BS EN 730-2:2002 Gas welding equipment. Safety devices. Not incorporating a flame (flashback) arrestor