UNIVERSITY OF BIRMINGHAM

Health and Safety Policy

Compressed Gas

UHSP/20/CG/03

This document sets out in more detail the arrangements for compliance with University Health and Safety Policy at Budget Centre level and it gives guidance on how these requirements may be met. This document forms a part of the University Health and Safety Policy. It has been approved by the Environment, Health and Safety Executive Committee, in consultation with the Joint Safety Advisory Committee, and it will be subject to review.

Compressed gas in cylinders and disposable cartridges is a convenient way to transport and store gases under pressure - a lot of gas is contained in a small volume. Compressed gas cylinders are therefore pressure vessels. If, as a result of mishandling or misuse or overheating, the full gas pressure were to be suddenly released, they can become very dangerous projectiles that can cause serious injury or even death. There are also risks associated with the hazardous properties of the particular gaseous substances. This Policy should be used in conjunction with University Hazardous Substances Policy (UHSP/15/HS/03).

This document sets out Policy and requirements for compressed gas safety and further information and guidance on the hazards, equipment and procedures.

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Compressed Gas
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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, behaving just as a toy balloon does if it is let go before the end is tied up. 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.

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.

POLICY

Heads of Budget Centres must make arrangements to ensure that, in accordance with the requirements of this Policy:

Information, Instruction and Training

- users of compressed gas are aware of the requirements of this policy and are given adequate information, instruction and training to enable them to work safely with compressed gas;
- persons who install or carry out maintenance on compressed gas equipment are adequately trained and competent to carry out the work;

Inspection, Testing and Service

- all compressed gas equipment is subject to an annual maintenance inspection and functional checks as specified in the schedule to this policy;
- pressure regulators and flashback arrestors are considered for replacement/refurbishment after 5 years or in accordance with the manufacturer's recommendation;

Transport

- movement of gas cylinders between buildings or transport by road is in accordance with the requirements of Schedule 6 of Hazardous Substances Policy;

Storage

- compressed gases are stored in accordance with Hazardous Substances Policy, Schedule 5.

Individuals must:

- comply with the requirements of this policy;
- carry out the pre-use checks as specified in the schedule to this Policy.

REQUIREMENTS FOR WORK WITH COMPRESSED GAS

Information, Instruction and Training

1. Persons who install or carry out maintenance on compressed gas equipment must be adequately trained and competent to carry out the work.
2. Users of compressed gas must be given information, instruction and training sufficient to enable them to understand the risks associated with gas cylinders and cartridges and their contents and to be able to work safely.

Inspection, Testing and Service

(for details see the schedule attached to this Policy)

3. Before each period of work, users must 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.
4. All joints, from the cylinder/cartridge through the gas equipment, must be checked regularly for leaks at the working pressure.
5. All compressed gas equipment must be subject to an annual maintenance inspection and functional checks, in accordance with the schedule attached to this Policy.
6. Pressure regulators and flashback arrestors should be considered for replacement/refurbishment after 5 years or in accordance with the manufacturer's recommendation.

Equipment

7. A suitable pressure regulator must be fitted to a 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.
8. Users must not tamper with gas regulators or attempt repairs.
9. The gas regulator and pipework/hose must be suited to the type of gas and the pressures involved.
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.

Working Practices

14. Acetylene must not be used at pressures above 9psig (0.62 Bar/0.062MPa).
15. The cylinder valve must be closed at all times when the gas is not in use.
16. The regulator pressure adjusting screw must be returned to the zero position (fully anticlockwise) when the regulator is not in use.
17. Cylinders must be protected 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.
18. Personal protective equipment must be used to protect eyes, hands, feet, as appropriate, when working with gas cylinders
19. A clamp attached to a wall or other rigid structure or a stable stand must be used to secure gas cylinders.

20. Gas cylinders must be used in a vertical position, unless specifically designed to be used otherwise.
21. Where the gas is incompatible with air or water the system must be purged before use.
22. Oxygen equipment must be kept free of oil and grease.

Transport

23. A cylinder trolley must be used when cylinders are moved from place to place.
24. Movement of gas cylinders between buildings or transport by road must be in accordance with 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.

Storage

25. Compressed gases must be stored in accordance with Hazardous Substances Policy, Schedule 5.
26. Gas cylinders and cartridges that are not in use must not be stored within laboratories or workrooms.

Disposable Cartridges and Portable Equipment

27. Disposable cartridges which do not bear a "use by" data must be date marked with a date for disposal one year from the date of acquisition or with a date based on the manufacturers recommendation.
28. The connection and disconnection of LPG containers from appliances must only be carried out in a well ventilated place, preferably in the open air, away from possible sources of ignition and only when the appliance is cold.
29. Neither full nor empty LPG cartridges must be placed in internal waste bins. Full cartridges must be emptied in a safe place before disposal.
30. LPG cartridges must be used or disposed of by the "use by" or "disposal date".

Emergencies

31. Procedures for dealing with emergencies involving compressed gas are detailed in Hazardous Substances Policy Schedule 8.

FURTHER INFORMATION AND GUIDANCE

Uses of compressed gas include:

- soldering, welding and flame cutting;
- breathing (eg diving, emergency rescue);
- medical;
- laboratory experiments;
- dispensing beverages;
- fuel for vehicles (eg fork-lift trucks);
- extinguishing fires;
- heating, cooking and lighting;
- water treatment.

The main hazards of compressed gas are:

- impact from the blast of a gas cylinder explosion or rapid release of compressed gas;
- impact from parts of gas cylinders that fail, or any flying debris;
- inhalation of released gas or contact with released gas or fluid;
- oxygen deficiency caused by the release of any gas other than oxygen;

- fire and even explosion resulting from the ignition or escape of flammable or oxidising gases or fluids;
- the bursting of overheated cylinders;
- impact from falling cylinders;
- manual handling injuries.

The type of gas: hazards are also dependent on the form in which the gas is present in the cylinder:

- Liquefied compressed gas - some gaseous substances turn to liquid when compressed, e.g. LPG
- Gaseous compressed gas
- Dissolved compressed gas, e.g. acetylene

The main causes of accidents are:

- inadequate training and supervision;
- poor installation;
- poor examination and maintenance;
- faulty equipment and / or design (e.g badly fitted valves and regulators);
- poor handling;
- poor storage;
- inadequately ventilated working conditions;
- hidden damage.

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 include: 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.

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

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;
- 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

Pressure Regulators

For most uses the pressure of gas in a cylinder is too high. A pressure regulator is used to 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.

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.

Older regulators may not be able to withstand current cylinder pressures. For various reasons, some cylinder filling pressures have increased over the years. The regulator specification must be checked to ensure it can cope with the current maximum cylinder pressure.

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

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.
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.

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.

SCHEDULE

Inspection and Testing

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.

Annual Maintenance and Examination

Pressure Regulators

- The items listed above.
- Functional tests to ensure correct operation.

Flashback Arrestors

- The items listed above.
- Check for flow restriction and, where fitted, non-return valves;
- Reverse flow to ensure correct operation of internal components;
- If of pressure sensitive type, check for flow in opposite direction with valve tripped;
- Test pressure sensitive shut-off valves for correct operation.

Hose Assemblies (including non-return valves)

- The items listed above;
- Reverse hose to check correct operation of non-return valve;
- Bend hose in a tight radius to check that:
    - reinforcement is not visible;
    - there are no splits or other signs of deterioration.

REFERENCES

Gas Cylinder Colour Coding

BS EN1089-3:2011 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**.

Hose and Tubing Standards

BS EN ISO3821 2010 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

BS EN 15908:2010 Anaesthetic and respiratory equipment. Non-interchangeable screw-threaded (NIST) low-pressure connectors for medical gases

BS 8789:2009 Rubber hoses and hose assemblies for liquefied petroleum gas in motor vehicles

BS EN ISO 2398:2008(under review) Rubber hose, textile reinforced, for compressed air. Specification

Regulator Standards

BS EN 16129:2013 Pressure regulators, automatic change-over devices, having a maximum regulated pressure of 4 bar, with a maximum capacity of 150 kg/h, associated safety devices and adaptors for butane, propane, and their mixtures

BS EN ISO 2503:2009 Gas welding equipment. Pressure regulators for gas cylinders used in welding, cutting and allied processes up to 300 bar

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

BS EN ISO 10524-3:2006+A1:2013 Pressure regulators for use with medical gases. Pressure regulators integrated with cylinder valves

BS EN ISO 7291:2010Gas welding equipment. Manifold regulators used in welding, cutting and allied processes up to 200 bar

Safety Devices

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

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