UNIVERSITY of CAMBRIDGE
DEPARTMENT OF ENGINEERING
HOPKINSON LABORATORY

HEALTH AND SAFETY GUIDANCE

1 INTRODUCTION

Your induction has emphasised the importance of carrying out a risk assessment for your experimental work. In fact, the technical staff have been told that if they do not see a risk assessment, they must not work on your equipment.

You know about many of the dangers of the work you are planning, but the most important aspects of a risk assessment are to consider all the foreseeable hazards and to either avoid them altogether or to put in place controls which will reduce the risk of an accident or ill-health (to you, or to others in the area) to an acceptable level. That is, acceptable to the University and the law, not just to you.

Some hazards are not foreseeable to you, because of lack of knowledge or experience; this guidance document aims to help you identify potential risks, including those that are less well known and to determine the controls that are considered to be good practice.

The nature of the experimental work carried out in Hopkinson Lab with flammable substances means that there are significant risks of fire or explosion. The substances and their products of combustion may also be hazardous to health. However, it is important not to neglect what might seem like less serious hazards since they may be much more likely to happen.

1.1 Flammable substances

These include flammable liquids such as acetone, heptane, kerosene; flammable gases such as hydrogen; liquefied petroleum gases (LPG) such as butane and propane; and combustible dusts. The use of oxygen / oxidisers must also be considered carefully as they can contribute to the strength of a fire or in certain circumstances spontaneously ignite. But don't forget other less common flammable substances – solvents, paints, varnishes etc.

The risk associated with a flammable substance depends on both its flammable and its physical/chemical characteristics, e.g.:

- Flashpoint.
- Minimum ignition energy.
- Volatility.
- Auto-ignition temperature.
- Gas or vapour density.
- Viscosity.
- Explosion limits.

Flammable liquids are labelled with R10, R11, R12 or R17 on the material safety data sheet (MSDS) and transport label, they will also have an orange warning label.

R10	Flammable	Flash point ≥21^{o}C ≤55^{o}C
R11	Highly flammable	Flash point ≥0^{o}C ≤21^{o}C
R12	Extremely flammable	Flash point ≤0^{o}C
R17	Spontaneously flammable in air	

Substances with higher flashpoints may also be dangerous if they are heated or exposed to temperatures above their flashpoint or are generated as a mist or spray, spread thinly over the ground or spilled onto clothing.

1.2 Other Hazards

These include electricity, slips trips and falls, mechanical injury (cuts, blows, trapping, entanglement, shearing), ejected items, heat/cold, noise/vibration, chemicals, display screen equipment (computers), manual handling, confined spaces, high pressure fluid injection, ionising/non-ionising radiation, biological agents, asphyxiation, energy release from compressed gases.

To help you identify these hazards, a list, with examples has been prepared in Appendix 1.

2 STORAGE OF FLAMMABLE SUBSTANCES

2.1 Main Storage Areas

There are storage areas for:

- flammable gases/oxygen,
- oxidisers,
- LPG,
- flammable liquids with flashpoint above 32^{o}C and
- flammable liquids with flashpoint below 32^{o}C.

Make sure you know where these areas are.

2.2 Quantities

To reduce the risks, you should make sure that the quantity of flammable substance kept in the laboratory is as small as possible, suitable for up to a half day's operation. This should be not more than 2 litres except what is in the cylinder/fuel tank for the equipment. You should purchase suitably sized containers/cylinders and return any excess to the proper storage cupboard or area.

2.3 Storage cupboards in the laboratory

Small quantities of flammable liquids may be kept in closed containers in a suitable fire resisting cupboard or bin designed for the purpose and located in the laboratory. For liquids with a flashpoint below 32^{o}C, the maximum quantity is 50 litres in each workroom. For liquids with a flashpoint above 32^{o}C, this quantity is 250 litres.

Check the actual flashpoint of the liquid, given on the material safety data sheet, before deciding on the storage location.

Note: 32^{o}C is considered to be the maximum normal ambient temperature; therefore substances with a higher flashpoint will not normally generate a flammable atmosphere unless heated, but will burn if involved in a fire.

The cupboard / bin should be kept closed.

2.4 Ventilation

You should store or use flammable substances in a well-ventilated area to dilute any releases to a safe level. The minimum requirement is 6 air changes per hour.

2.5 Signs and labels

Flammables in their original containers should be properly labelled.

However, if liquids are transferred to an intermediate container, this must be labelled with a hazard sign showing the fire logo. You must also make sure that the name of the substance is marked clearly on the container.

All storage areas and cupboards must be clearly marked with this warning sign together with sign(s) stating "No Smoking. No naked flames".

2.6 Empty Containers/Cylinders

Drums or containers which have been emptied but not gas freed, are still potentially dangerous and must be labelled and handled as if they were full.

3 DESIGN

Good design, taking account of the hazards raised by the risk assessment is essential for safe working. The risks are influenced by the particular circumstances of the work you are carrying out. The design of the equipment and the way it is used can significantly affect these risks, e.g.:

- The form of the flammable substance - liquid, solid, gas, vapour, mist, spray.
- Where and how liquids are dispensed.
- If the process or environment increase the temperature of the substance.
- How much ventilation is available to disperse a flammable atmosphere.
- Could containment of the equipment improve its safety.
- Whether gas or vapour can build up in low level pits or overhead areas.

When considering risks from releases of flammable substances you should include:

- unavoidable releases, e.g. from vents;
- intentional releases, such as your combustion process; and
- foreseeable releases, for example leaks from process equipment or storage containers, or spills during dispensing.

To make sure that flammable substances are handled and used safely, all experimental equipment should be risk assessed in accordance with the Dangerous Substances and Explosive Atmospheres Regulations. A ‘Dangerous Substance’ in the regulations is the same as ‘flammable substance’ in this guidance.

The aim of these regulations is to avoid creating a potentially flammable atmosphere, or if that is not possible, to prevent ignition sources igniting the atmosphere. Where ignition is the intention (e.g. in your experimental work) you will need to provide alternative measures to control the risks or mitigate the effects. For further details see Appendix 2.

Complying with the good practice requirements in this section will go a long way towards ensuring that the requirements of DSEAR are met.

3.1 Ignition Sources

Obvious Ignition sources include heat, naked flames and electrical equipment; it may be less obvious that mechanical equipment, electrostatic charges, lasers, and spontaneous ignition can all cause fires or explosion.

If your risk assessment has identified that there are areas where a flammable atmosphere could occur, you will need to ensure that any electrical equipment in these areas is of a suitable standard to avoid ignition, (see Appendix 2).

Electrostatics is often underestimated as an ignition source, but must be taken into account, particularly when dealing with flammable liquids and combustible dusts. These readily develop their own electrostatic charge by movement relative to a low conductivity material. Liquids free-falling into a vessel or passing through a filter can generate significant charge.

Appropriate earthing is essential to avoid these charges generating a spark.

Note that you can also generate a charge on your body and act as the cause of a spark, potentially igniting any flammable atmosphere with a sufficiently low minimum ignition energy (MIE).

In some cases anti-static footwear and tight fitting clothing will be needed.

3.2 Protective devices

Flammable liquids should preferably be handled in a closed system – pipework, pumps, closed vessels. After eliminating or reducing risks as far as you can by design and safe operation, you need

to consider whether there is still a risk of fire or explosion that requires the use of protective devices. These include:

- Flashback arrestors (FBAs) to prevent flames from burning back into the equipment.
- Pressure relief valves, explosion panels and vents to avoid catastrophic failure of equipment. Note: These must all be sited carefully to avoid a fire or explosion or further damage from their operation.
- Sensors to detect the presence of a flammable atmosphere.
- Fire suppression such as CO_2 or water mist.
- Earthing to dissipate electrostatic charges.

3.3 Bunding

Where there would be a risk from leaks or spills of flammable liquids (or LPG) spreading over a large area the container should be bunded, that is, placed into an outer container that will hold 125% of the volume of the flammable liquid container.

3.4 Ventilation

Suitably designed ventilation can be very effective in preventing an explosive atmosphere forming or in dispersing it so that it does not last for long. This may be general ventilation for the whole room, or local exhaust ventilation (LEV) that is designed to remove leaks of flammable substances or unburnt portions of fuels at the point where they are released.

You should consider whether general ventilation is adequate or if your experiment requires LEV. Should ventilation be left running at all times? Is the scavenging effect adequate to prevent a flammable atmosphere forming in any part of the area? Is it appropriate for the buoyancy of the gas or vapour? – e.g. hydrogen is very much lighter than air, but LPG vapour is heavy and will tend to enter low lying areas. If the ventilation is essential to prevent a flammable atmosphere forming, should there be a flow sensor to warn you if it fails?

Are you confident that the ventilation is sufficient to dilute the flammable gas/vapour to below 10% of its lower explosive limit (LEL) in the work area (or <25% in an enclosure)? Is the ductwork exhausted to a safe place?

Note: If there is a workplace exposure limit (WEL) for the substance because it is hazardous to health, this is likely to be significantly less than 10% of the LEL.

If providing vent pipes on equipment, e.g. to prevent overpressure/vacuum, these should vent to the outside and end at least 5m above ground level and 3m from building openings, boundaries, sources of ignition. If the vessel contains a substance with flash point less than 21^{o}C, the vent will need a flashback arrestor.

Take great care if you are requesting modification of existing LEV or other ventilation – the changes may compromise the performance of existing systems. LEV should be thoroughly tested every 14 months by a competent person, and will need retesting if it is modified.

Ductwork should be fire resisting, and unprotected fan motors should not be sited within the ductwork. Fans and motors should be of a suitable category for a potentially flammable atmosphere. See Appendix 2 – Ignition Sources.

3.5 Shut-off

Ensure there are sufficient valves for isolation: after use, in an emergency and for maintenance. Label them clearly.

Provide appropriate electrical isolation, clearly labelled and suitably located for use in an emergency.

Consider whether your equipment needs the added protection of an automatic shut-off in the event of an emergency, e.g. a leak, spill or fire. If not, have you fully considered the requirements for a manual shut-off? Make sure that you and others know how to do this.

3.6 Electrical equipment

The design of electrical systems should only be undertaken by a competent person. Discuss this with your supervisor and the Senior Design Engineer.

3.7 Laser safety

To protect you and others in the area, equipment using lasers is partitioned off with the door interlocked to the laser control system. You should consult closely with the Department Laser Safety Officer in specifying your requirements.

3.8 Pressure systems

The need to provide a written scheme of examination, to carry out inspections and other requirements applies to certain pressure systems. The Senior Design Engineer will arrange for these requirements if you inform him that your equipment is a pressure system.

A pressure system is one of the following that contains a relevant fluid:

- a system comprising one or more pressure vessels of rigid construction, associated pipework and protective devices;
- the pipework with its protective devices to which a compressed gas cylinder is, or is intended to be, connected; or
- a pipeline and its protective devices,

The system does not include the compressed gas cylinder.

A relevant fluid is:

- A fluid or mixture of fluids, which are gases at > 0.5 bar above atmospheric pressure, e.g. methane, or which become gas when released to the atmosphere, e.g. LPG.
- Gas dissolved under pressure in a solvent, e.g. acetylene.
- Steam at any pressure.

Note: If the pressure vessel has a combined pressure x volume of less than 250 bar-litres, then the system will be exempt from some requirements (unless it contains steam).

3.9 Noise assessment

You should assess whether you may be exposed to too much noise by checking if the following happens:

- Intrusive noise for most of the working day.
- Raising your voice to have a normal conversation when only 2m apart – for at least part of the day.
- Using noisy powered tools for more than ½ hour per day, e.g. power drill.
- Noise due to impacts for even a short time, e.g. hammering.

If this is the case, ask for a noise assessment to be carried out. You should try to reduce the noise level at source, e.g. by soundproofing the equipment though if this is not sufficient, hearing protection may also be needed. Make sure other people aren't at risk too.

If you need to enter an engine test cell, you must wear hearing protection. The test cell will only provide protection for the hearing of people outside if the doors are closed and there are no gaps for the sound to escape through.

3.10 COSHH Assessment

You must carry out an assessment of the risks from substances hazardous to health (a COSHH assessment), on the departmental form. This will help you to identify, for example, whether you need to use a fume cupboard or LEV, what PPE is needed, how to store and dispose of the substance and actions to take in an emergency.

Where possible you should try at the design stage to remove the hazards or control them by engineering means before resorting to wearing personal protective equipment (PPE).

When using toxic gases which could leak into an area (e.g. carbon monoxide) you should fit a detector to warn of dangerous levels of the gas. Only 1% by volume of carbon monoxide, for example, is likely to make you unconscious within a few breaths and dead in a few minutes.

3.11 Supervision

Discuss your design with your supervisor who will review it and if there are any concerns, discuss it with the Design Engineer.

4 INSTALLATION

4.1 Competence, training and supervision

Anyone installing equipment to contain flammable gases must be competent. The departmental technicians have been trained and certified to install gas systems, but there will be some parts of the work that you will need to carry out. The technicians will demonstrate the key skills needed to assemble or install this equipment and will check your competence to do this. You must not attempt to carry out work for which you do not have the skills.

You may assemble electrical equipment if you are competent, but only the engineer authorised to give power must connect the equipment. If you carry out any modifications to this electrical equipment, it must be done with the power to the equipment isolated and it must be checked by the engineer authorised to give power before being reconnected.

If there are any concerns about the design or installation of the equipment, discuss the issues with your supervisor or with the Senior Design Engineer.

4.2 Good practice

4.2.1 General

Never ‘snift’ hydrogen. This is the practice of letting a small amount of a compressed gas escape from the cylinder to clear dust from the threads before fitting a regulator. Hydrogen can spontaneously ignite if this is done.

Sparks may be generated by the use of steel tools. Use non-sparking tools (usually nickel-aluminium-bronze) when working on pipework or in areas where there may be a flammable atmosphere.

Always use standard components where these have been identified, e.g. Swagelock fittings for gas pipework.

Do not use oils, greases or even PTFE tape for oxygen (or nitrous oxide) fittings. They can spontaneously ignite in the presence of these gases; so use specially degreased components for pipelines. If an oxygen cylinder is contaminated with grease or oil, return it to the supplier.

Ductwork must not allow vapours to collect or condense at low points.

Make sure that flammable residues do not build up on or in equipment, particularly the ductwork. Clean regularly if this is a risk.

The engine test cells will only provide the fire resistance they have been designed for (30 minutes) if the doors are closed and there are no gaps in the walls, floors or ceilings. Make sure that gaps are filled with suitable materials and doors are kept closed.

4.2.2 Regulators and safety devices

Pressure regulators must be fitted to compressed gas cylinders before use. Our technical staff or the BOC representative will show you how this is done or do it for you. Do not use a regulator with outlet pressure higher than your system’s safe working pressure; the pressure setting may inadvertently be increased.

Safety devices:

Application	Gas	Protective device required
More than one gas with ignition source	Oxygen and flammable	Non-return valve in hose assembly at process equipment connection. Flashback arrestor and cut-off valve at regulator outlet connection of both gas supply lines
Individual gas with no ignition source	Oxygen or flammable	Consider non-return valve Consider flashback arrestor
More than one gas simultaneously	Inert	Consider a non-return valve

Consider if hydrostatic relief valves are required on liquid systems to prevent damage from thermal expansion.

4.2.3 Gas Hoses

Hoses and their assemblies (i.e. tails and clamps) must be compatible with the gas(es) and the pressure to be used, check this with the supplier.

Do not use reusable worm-drive clamps (jubilee clips) for gas hoses.

Hoses are colour coded and fitted with left or right hand threads to avoid confusion:

Gas	Hose Colour	Thread
Oxygen	Blue	RH
LPG/Methane	Orange	LH
Hydrogen/Acetylene	Red	LH
Inert gases	Black	RH
Mixed gas (flamm and inert)	Red	LH
Mixed gas (oxygen and inert)	Blue	RH

It is appropriate to use small-bore metallic tubing for most purposes instead of hoses; label it clearly if the contents are not obvious.

Do not use hoses which are longer than needed – a fire in a coiled hose is difficult to put out.

Do not use hoses to create a piped system to several locations.

4.2.4 Flammable liquid hoses and pipework

Make sure that the material of pipework, valves, seals etc. is compatible with the substance being used, and if plastic, that there is not an increased risk from electrostatic charges.

Select pipe dimensions to reduce their content to a minimum.

Use liquid hoses only where their flexibility is required e.g. for filling or to isolate vibration.

To avoid electrostatic charges building up, all conducting parts must be earthed. Permanent components should be bonded together and adequately earthed. Temporary components such as containers should be earthed with a clip connected to the earthed equipment. Hoses should be electrically continuous or bridged with an earthing cable to avoid electrostatic charging.

5 USE

Experimental work may only be carried out between the hours of 9am and 5pm, Monday to Friday and not on weekends or Bank Holidays. It should not be carried out behind closed doors and you should ensure that someone knows where you are and what you are doing – no lone working.

You should never operate a laser from inside the laser room, unless the set-up has specifically been designed for this and has the written approval of the Department Laser Safety Officer.

All experimental areas are restricted to authorised personnel only. Do not let your curiosity get you into trouble; if you are not authorised, keep out.

5.1 Safe Working Practice

5.1.1 General

Keep work area clear of slip and trip hazards and flammable/combustible materials. Make sure you know where the nearest suitable fire extinguishers are.

If you find that flammable substances or oxygen gas have contaminated your clothing/lab coat, you should remove it promptly. These substances can remain in the cloth for some time and any may ignite easily.

Make sure you know the safe operating limits of the system and have suitable operating and maintenance instructions.

When purging make sure the gas is released safely.

Have minimum quantities of flammable substances for use, preferably not more than you need in a half-day.

5.1.2 Compressed gases

Never use oxygen to freshen the air, this is very dangerous.

Acetylene is unstable as well as being highly flammable. Treat an acetylene cylinder gently as mechanical shocks or overheating can cause the acetylene to decompose and it may explode even without oxygen/air being present. Acetylene must not be used at pressures in excess of 0.62 bar (9 psi).

Do not damage pressure regulators by treating them roughly. Damaged regulators must be replaced.

Open cylinder valves slowly, using the proper tool, to avoid stressing the regulator (and prevent ignition due to adiabatic compression for oxygen cylinders). Once open close a quarter turn so others can tell if it's open or closed.

Use only the correctly labelled regulator for the gas and the maximum cylinder pressure.

When not in use, close the cylinder valve, and set the regulator pressure to zero.

Do not expose cylinders to heat.

5.1.3 LPG

Do not use LPG near to drains, pits or other low lying areas; the vapour can travel long distances.

5.1.4 Cylinder handling:

- Cylinders are heavy, if you need help to move one always ask.
- The BOC technician will deliver a cylinder to your work area and connect it if you require.
- Use cylinder trolleys where available.
- Wear gloves and foot protection.
- For short distances, 'churn' the cylinder, i.e. tilt it slightly and rotate it on its bottom ring.
- Never roll a cylinder horizontally.
- Do not move a cylinder with the valve open.
- If the cylinder has its regulator/hose attached, only move it on a proper cylinder trolley.

Secure all cylinders in a vertical position so they cannot fall.

5.1.5 Flammable Liquids

Use proprietary safety containers for dispensing and storing flammable liquids, these are fitted with self-closing lids and flashback arrestors. If they are plastic, they should incorporate anti-static features.

Keep the lids on flammable liquid containers closed when not in use.

Do not decant from a large container in the storage area; preferably do this in the open air or a separate well-ventilated room. Use a drum pump, funnel, drip tray, hose as necessary to avoid spills. Use suitable earthing leads and clips and electrically conducting hoses to avoid electrostatic charges building up.

5.1.6 Carbon monoxide poisoning

Carbon monoxide (CO) is a highly poisonous gas, which is difficult to recognise, as it has no colour, smell or taste. It affects mental ability causing a person to become incapable without knowing.

Symptoms of CO poisoning can initially seem similar to a viral infection. They include:

- Tightness across the forehead
- Severe headache
- Weakness, dizziness, nausea, vomiting.
- Coma, intermittent convulsions
- Depressed heart action, slowed respiration.

If the exposure has been severe it may cause death.

6 USER MAINTENANCE / INSPECTIONS

6.1 Compressed gas systems

Check according to the manufacturer's instructions, including:

Equipment	Each time the equipment is used
Regulators and flashback arrestors	Visually check condition (gas type, pressure rating, damage, threads and sealing surfaces) Check that they are not contaminated with oil or grease. Leak test all joints at working pressure using a proprietary leak testing fluid.
Hose assemblies (and non-return valves)	Visually check condition (gas type, pressure rating, damage, threads and sealing surfaces). Check condition of cover (kinking, twisting). Check whip restraints if fitted (needed if > 40 bar). Leak test all joints at working pressure using a proprietary leak testing fluid.

6.2 Flammable liquid systems

Visually check the condition of flexible hoses for flammable liquids each time the equipment is used. Look for leaks, wear and mechanical damage.

6.3 Good Practice

Always make sure that pressure has been relieved from a system before unscrewing/removing components, they could otherwise turn into a missile as they reach the last threads, or liquid could be ejected under pressure.

Blank off any pipework that has been disconnected, to prevent a valve being opened inadvertently and releasing flammable gas or liquid.

Wherever possible, make sure all sources of a flammable atmosphere are removed and purged before maintenance work is started.

Electrical inspections and testing of both portable appliances (fitted with a plug) and fixed installations will be carried out at suitable intervals. Make sure your electrical equipment is within the test date or have it re-checked.

7 DISPOSAL

You should always consider how to safely dispose of unused or waste flammable substances. This should include burnt and unburnt fuels (gaseous and liquid) and purging gases. Follow the department's disposal procedures for waste substances and ensure that emissions to atmosphere are both safe (consider health and fire dangers) and environmentally legal.

Never put flammable liquids into the drains.

Do not mix waste substances unless it is known that they are compatible. Ensure the waste container is properly labelled. Always use a funnel to avoid spills; they are available with lids and flame arrestors if this will improve safety.

Replace waste containers in storage cabinets or areas when not in use, but do not fill them in the storage area.

Put any materials contaminated with flammable substances (e.g. cleaning rags) into a metal bin fitted with a self-closing metal lid. Make sure these are emptied daily – as well as being a fire hazard, they may spontaneously ignite.

Containers that are nominally empty will contain vapour or gas at atmospheric pressure unless they have been gas freed. They must be gas freed, or labelled and handled as if they were full.

All dismantled experimental equipment must be safely emptied and disposed of. Do not keep parts (except for measurement equipment) in the hope that they may be useful in the future, they simply make housekeeping more difficult. If necessary, the equipment must be decontaminated before disposal or marked clearly with the substances that have been used.

8 EMERGENCY

In the event of an incident, follow the departmental emergency plan. However if this is not suitable for your equipment or process, prepare additional emergency procedures and make sure all relevant people are aware of them.

Make sure you have a suitable shut down procedure for your equipment in the event of an emergency. This may be manual or automatic.

Make sure that suitable fire fighting, spill control and personal protective equipment is available to deal with your emergency.

For spills, once inert absorbent material has been used it must be scooped up and placed in a metal container for disposal.

For a large spillage or where the substance is hazardous to health, you will need to evacuate the area and if necessary call the fire brigade to assist in dealing with the spill.

Never operate electrical switches (on or off) when there has been a spill or leak.

Information is provided for the emergency services, such as the location of hazards. Make sure that you have informed [who?] of the type, quantity and location of your flammable substances and do not alter this without notifying them.

9 MANAGEMENT

To help reduce the risks associated with the work being carried out in the laboratory, there are a number of management controls in place. These include:

- Supervision
- Restriction of access
- Provision and maintenance of safe storage areas.
- Checks on housekeeping
- Informal and formal safety monitoring/inspections, including a safety tour.
- Control of pressure systems – a written scheme of examination and regular insurance inspections
- Management of local exhaust ventilation (LEV) – 14 monthly thorough examination and test
- Inspection, testing and replacement of regulators, flashback arrestors, non-return valves and hose assemblies.
- The use of permits to work in hazardous areas
- Electrical inspections and testing of portable appliances and fixed installations at suitable intervals.
- Provision and maintenance of fire detection and fire-fighting equipment, spill control materials and personal protective equipment (PPE).
- Maintenance of escape routes and emergency lighting.
- Training for awareness, design, installation, use, maintenance, disposal, and emergency.

10 FURTHER INFORMATION

L 138	Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) code of practice and guidance	Health and Safety Executive (HSE)
HSG 51	Storage of flammable liquids in containers	Health and Safety Executive (HSE)
HSG 140	Safe use and handling of flammable liquids	Health and Safety Executive (HSE)
BS EN 60079-10:2003	Electrical appliances for explosive gas atmospheres – classification of hazardous areas	British Standards Institute (BSI)
CLC/TR 50404:2003	Electrostatics, code of practice for avoidance of hazards due to static electricity	British Standards Institute (BSI)
COP 20	Training in gas installation	Health and Safety Executive (HSE)
GN7	The safe use of individual portable or mobile cylinder gas supply equipment	British Compressed Gas Association (BCGA)
GN2	Guidance for the storage of gas cylinders in the workplace	British Compressed Gas Association (BCGA)
INDG 327	Take care with acetylene	Health and Safety Executive (HSE)

APPENDIX 1

LIST OF POTENTIAL HAZARDS

Hazard	Examples
Slips, trips, falls (on level)	Trip hazards, trailing cables, unmarked steps, wet floors, spills of liquids or granules.
Falls from height	From ladder/step stool, into excavation/open manhole.
Impact from objects	Falling/ejected/moving – Items stored at height, sensor removed under pressure, dust / particles.
Mechanical injury	Cut/crush/puncture - knife cut, shearing/spearing from equipment
Entanglement (hair/clothing)	On rotating shaft
Trapping by machinery	Belts, gears – in-running nips
Thermal	Heat, cold (environmental and surfaces), steam. LPG cold burns.
Electric shock/burn	Use of faulty equipment, tampering with plugs or opening electrical cabinets/casings.
Noise/vibration	Engine noise, hand-arm vibration syndrome..
Chemicals	Dust/liquid/mist/fume/vapour/gas - breathed in, ingested, in eyes, on skin. Toxic, corrosive, sensitising, carcinogenic.
Display screen equipment	Eye strain, muscle problems, stress
Manual handling	Musculo-skeletal problems, repetitive injuries, load and frequency, awkward positions.
Fire/explosion	Fuel, oxygen, ignition. Flammable liquids, gases. Generating flammable atmospheres, e.g. evolving hydrogen
Confined spaces	Excavations, closed vessels/rooms, silos. Lack of breathable atmosphere, difficulty of escape, explosive build up.
High pressure fluid injection	Compressed air, hydraulics. Subcutaneous injection of air.
Ionising radiation	X-rays
Non-ionising Radiation	Lasers, UV from arc welding, RF – radio frequency, microwaves – causing heating, deep burns, affecting pacemakers
Biological agents	Legionaire's disease, food poisoning, hepatitis, micro-organisms,
Lead	Including alkyls, alloys, compounds, constituents liable to be inhaled, ingested or absorbed.
Collapse of structure	Racking, mezzanine floor, scaffolding, building
Dangerous atmosphere	Asphyxiation – quantity of gas/ ventilation of room.
Sharps/sharp edges	Needles, sheet metal/glass, machinery blades, knives
Compressed gases/fluids	Energy release
Lighting	Eye strain, accidents due to poor lighting.

APPENDIX 2

THE DANGEROUS SUBSTANCES AND EXPLOSIVE ATMOSPHERES REGULATIONS 2002 (DSEAR)

These regulations require employers to control the risks to the safety of employees and others from fire and explosions.

Employers are required to:

- identify dangerous substances in the workplace and the fire and explosion risks;
- put measures in place to either remove those risks or, where this is not possible, control them;
- put controls in place to reduce the effects of any incidents involving dangerous substances;
- prepare plans and procedures to deal with accidents, incidents and emergencies involving dangerous substances;
- make sure employees and others, e.g. students, post-docs, placements, are properly informed about and trained to control or deal with the risks from the dangerous substances;
- identify and classify areas of the workplace where explosive atmospheres may occur (hazardous areas) and avoid ignition sources in those areas.

Hazardous Area Classification

Hazardous areas fall into 3 types of Zone in which flammable concentrations of gas, vapour or mist may be present:

Zone 0 An area in which an explosive mixture is continuously present, or present for long periods, or frequently, e.g. inside storage containers or in the immediate vicinity of exposed liquid surfaces.

Zone 1 An area in which an explosive mixture is likely to occur occasionally or for short periods in normal operation, e.g. filling or sampling.

Zone 2 An area in which an explosive mixture is not likely to occur in normal operation, and if it occurs will exist only for a short period, e.g. spills and leaks caused by operator error or equipment failure.

Outside of these Zones the areas are defined as non-hazardous.

If the temperature of a liquid is unlikely to be raised above its flashpoint and there is little likelihood of a mist or spray occurring (which may ignite at temperatures below its flashpoint), the liquid may be considered not to give rise to a hazardous area. Any splashing or mist forming must be avoided or the area will need to be classified as hazardous and ignition sources removed.

The extent of the hazardous area will vary with the layout, design and ventilation of the plant and the nature of the substance handled (for example whether vapours are heavier or lighter than air). In some circumstances the ventilation will be sufficient to reduce the zone to a negligible extent, by dispersing the explosive atmosphere immediately.

Ignition Sources

Within the Zone, all electrical equipment should be of a suitable category based on the requirements of the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations:

Zone	Category
0	1
1	1 or 2
2	1, 2 or 3

It is also necessary to exclude other potential ignition sources from the Zones. Such sources may include:

- Portable electrical equipment (including battery operated);

- Flames;
- Direct fired space and process heating;
- Cutting and welding flames;
- Hot surfaces;
- Heated process vessels such as dryers and furnaces;
- Hot process vessels;
- Mechanical machinery;
- Spontaneous heating;
- Friction heating or sparks;
- Impact sparks;
- Electrostatic discharge sparks;
- Lightning strikes;
- Electromagnetic radiation;
- Lasers;
- Vehicles.

Where it is not possible to exclude ignition sources, e.g. the presence of an internal combustion engine, alternative measures are required for control of the risks or mitigation of the effects.

Note that these regulations also apply to combustible dusts.