Scope

Legal requirements
Identify associated hazards
Risk assessments and SOPs
Implement safe work methods and practices
Types of gases

- Compressed gases
- Cryogenic liquids
- Refrigerated liquids
Legislation and guidance:

• Dangerous Goods Act 2000
• Dangerous Goods (Storage and Handling) Regulations 2012

Australian Standards
• AS 2243.2: Safety in Laboratories: Chemical Aspects - is also an invaluable source of information regarding safe handling and storage of compressed gases.
• AS 1894: The storage and handling of non-flammable cryogenic and refrigerated liquids

• UoM Chemical Management Guidelines: http://safety.unimelb.edu.au/topics/chemical/guidance_index.html#general
• MSDS and SOP
<table>
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<tr>
<th>Standard Number</th>
<th>Title</th>
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<tr>
<td>AS/NZS 1596: 2014</td>
<td>The storage and handling of LP Gas</td>
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<tr>
<td>AS/NZS 1677.2:</td>
<td>Refrigerating systems - Part 2: Safety requirements for fixed applications</td>
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<tr>
<td>AS 1894</td>
<td>The storage and handling of non-flammable cryogenic and refrigerated liquids</td>
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<td>AS 1940: 2004</td>
<td>The storage and handling of flammable and combustible liquids</td>
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<td>AS/NZS 2022</td>
<td>Anhydrous ammonia - Storage and handling</td>
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<td>AS/NZS 2106.0 2005</td>
<td>Methods for the determination of the flashpoint of flammable liquids. (closed cup)</td>
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<td>AS 2187.1</td>
<td>Explosives - Storage, transport and use – Part 1: Storage</td>
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<td>AS 2337</td>
<td>Gas cylinder test stations (all parts)</td>
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<td>AS 2507</td>
<td>The storage and handling of agricultural and veterinary chemicals</td>
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<td>AS 2714</td>
<td>The storage and handling of hazardous chemical materials – Division 5.2 substances (organic peroxides)</td>
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<td>AS 2865</td>
<td>Confined spaces</td>
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<td>AS 2896</td>
<td>Medical gas systems - Installation and testing of non-flammable medical gas pipeline systems</td>
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<td>AS/NZS 2906</td>
<td>Fuel containers - Portable - plastic and metal</td>
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<td>AS/NZS 2927</td>
<td>The storage and handling of liquefied chlorine gas</td>
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<td>AS 3745</td>
<td>Planning for emergencies in facilities</td>
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<td>AS 3780</td>
<td>The storage and handling of corrosive substances</td>
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<td>AS/NZS 3833</td>
<td>The storage and handling of mixed classes of dangerous goods in packages and intermediate bulk containers</td>
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<td>AS 3961</td>
<td>The storage and handling of liquefied natural gas</td>
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<td>AS/NZS 4081</td>
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<td>AS 4289</td>
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<td>AS 4326</td>
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<td>AS 4332</td>
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<td>AS/NZS 4452</td>
<td>The storage and handling of toxic substances</td>
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<td>AS/NZS 4681</td>
<td>Storage and handling of Class 9 (miscellaneous) dangerous goods</td>
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<td>AS/NZS 4801</td>
<td>Occupational health and safety management systems</td>
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<td>AS4839</td>
<td>The safe use of portable and mobile oxy-fuel gas systems for welding, cutting, heating and allied processes</td>
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<tr>
<td>AS/NZS 5026: 2012</td>
<td>The storage and handling of Class 4 dangerous goods</td>
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<tr>
<td>AS/NZS ISO 31000</td>
<td>Risk management - Principles and guidelines</td>
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<tr>
<td>AS/NZS 60079</td>
<td>Electrical apparatus for explosive gas atmospheres (all parts)</td>
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</table>
You must complete a risk assessment for all gas work. Assessments need to cover:

- Handling
- Risks to health and safety
- Storage
- Use
- Waste management
- Spill and other emergency procedures

- See associated (M)SDS
- Risk assessments should be done before the work commences
- I can supply you with SOPs and RAs
• Store cylinders outside of the lab when not in use (dedicated gas storage rooms an exception to the rule)
• Cylinders must be restrained properly during transport, use and storage
• Do not store cryogenic gases in sealed containers, containers must be able to vent gases
• Do not use asphyxiates in small or unventilated rooms
• Install gas sensors and monitors if required
• Keep amounts to a bare minimum
• Refer to AS1984
Hazards associated with gases

All gases (compressed and liquefied) should be regarded as hazardous.

Hazards associated with the use of compressed gases:

• Compressed state – rapid expansion can take place, and with considerable force, when gas is released from the cylinder
• Low temperatures – some gases become cold when released rapidly. Cryogenic liquid gases are also naturally quite cold
• Reactivity (with other substances upon release)
• Poisoning
• Suffocation
• Burns – e.g. cold burns with cryogenic liquid gases
• Equipment failure – regulator, hoses and handpiece, control valves, the cylinder itself
• Manual handling
• Fire and heat
• Oxygen rich atmosphere
• Oxygen depleted atmosphere
Classification of gases

Class 2 Dangerous Goods are the gases:
These are then split in to sub-classes

- 2.1 Flammable gas
- 2.2 Non Flammable Non Toxic gas
- 2.3 Toxic gas
- 2.5 Oxidising gas

DG label  

GHS label
<table>
<thead>
<tr>
<th>Class</th>
<th>Type</th>
<th>Hazard</th>
<th>Examples</th>
<th>DG Diamond</th>
<th>GHS Pictogram</th>
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<tbody>
<tr>
<td>2.1</td>
<td>Flammable</td>
<td>Gases that can ignite in air on contact with a source of ignition.</td>
<td>Acetylene, LPG Hydrogen, Methane, Ethane</td>
<td></td>
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<tr>
<td>2.2</td>
<td>Non-flammable Non-toxic Gas</td>
<td>Gases that are non-flammable but may cause suffocation</td>
<td>Nitrogen, Argon, Helium, Carbon Dioxide, Carbogen, Sulphur hexafluoride, Cryogenic liquids, Refrigerated liquids</td>
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<tr>
<td>2.3</td>
<td>Toxic</td>
<td>Gases that are likely to cause death or serious injury if inhaled</td>
<td>Anhydrous Ammonia, Chlorine, Hydrogen fluoride, Carbon monoxide, Chlorine trifluoride</td>
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<tr>
<td>2.5</td>
<td>Oxidising</td>
<td>Gases that cause or increase the rate of combustion in other substances</td>
<td>Oxygen, Nitrogen oxides, Ethylene oxide</td>
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</tbody>
</table>
• Cylinders have labels on them, the same as any other chemical
• Cylinders are also colour-coded. However, always use colour-coding in conjunction with the affixed label as some companies import their products from other countries and other countries may use different coding systems.
• Regulators have two purposes:
  – flow rate
  – volume
• maximum life span (will depend on use and location)
• Serviced (every 5 years; Cyclical check list)
• No unauthorized repairs or modifications
• Each gas has its own type of regulator;
• Don’t use one that is not made for the gas you have. The seals and internal valve construction and type vary
• The valve (where the regulator attaches) is the weakest part of the cylinder.
• Cylinders are fitted with bursting disks to relieve pressure build up. If pressure builds up inside the cylinder, it will pop out the bursting disc in order to relieve the pressure.
• Cylinders are now set up so breathable gas fittings are different to inert gas fittings e.g. different type and size of valves and regulators
Cylinder anatomy

GAS CYLINDER PARTS

1. Cylinder Valve
   a. Valve Handwheel
   b. Valve Outlet Connection
   c. Pressure Relief Device
2. Valve Outlet Cap
3. Cylinder Collar
4. DOT Specification
5. Serial Number
6. Manufacturer’s Symbol
7. Test Date
8. Cylinder Cap
Cylinder risk management
Cylinder transport

- Never transport a cylinder with a regulator attached
- Do not travel with gas cylinders in the passenger cabin of the vehicle.
- Always have the cylinder secured appropriately
- Always use a trolley, don’t try to carry or roll/walk the cylinders
Cylinder transport – don’ts
• Cylinders must be secured appropriately at all times (even when empty, cylinders are never truly empty)
• Segregate incompatible gases
• Store empties separate to fulls – reduces manual handling issues and helps with inventory checks
• Do not store cylinders in labs unless they in use. ‘In use’ means, they must be secured, with a regulator and attached to equipment.
Label your cylinder

A tear off label that shows the status of the cylinder is a good idea
Gas cylinder storage – don’ts
Gas cylinder storage
Good storage solutions
When things go REALLY WRONG
Cryogenic liquids
Cryogenic liquids
Cryogenic liquids

Definitions

• Cryogenic liquid:
  – a liquid having a normal boiling point below -90°C at an atmospheric pressure of 101.3 kPa

• Dewar:
  – a portable, open necked, double walled, vacuum insulated container that is free venting and non-pressurized used for the storage of small quantities of low temperature liquids

• Refrigerated liquid:
  – liquid having a normal boiling point between -15 °C and -90 °C at an atmospheric pressure of 101.3 kPa.
Absence of warning properties

• It is a colourless liquid*
• As it boils off it generates gaseous nitrogen which cannot be detected by smell.

*If LN$^2$ has a blue or bluish tint to it, it contains liquid Oxygen.

Asphyxiation

• Only a relatively small volume of liquid nitrogen has to evaporate within a room to result in an oxygen deficient atmosphere. (<19.5% Oxygen)
Large expansion ratio during evaporation

- 1 litre of liquid nitrogen $\Rightarrow$ 682 litres of gas

Pressure build up &/or explosion

- Pressure can build up in a sealed container due to the boil off of nitrogen gas.
- An explosion can occur if the container is not rated to withstand the pressure
• Gas cylinders and dewars can be quite heavy when full
• Cylinders and dewars can be awkward to move around
• If a cylinder falls it can create a crushing hazard

• To manage these hazards:
  – Limit size/volume of containers
  – Provide suitable trolleys, ones with brakes preferred
  – Develop and implement appropriate procedures e.g. work with a second person when moving and transporting gases
  – Ensure that cylinders are secured properly
Hazard control

Elimination
• avoid the hazardous work or substance where possible.

Substitution
• use a less hazardous version of the gas. E.g. smaller vessels and/or other chemicals that are less hazardous.

Engineering controls
• Natural or forced ventilation;
• Use of equipment fit for use with cryogenic fluids;
• Regular inspection and maintenance program to ensure dewars, cylinders and equipment are in good condition.
• Install gas alarms e.g. Low oxygen, presence of flammable gases, high carbon dioxide
• Install emergency equipment such as safety shower and eye wash unit;
Administrative controls

- Training of persons using liquid nitrogen;
- Safe working procedures;
- Supervision and not working alone;
- Limited access to hazardous areas;
- Emergency response procedure;
- Good housekeeping;
- Good personal hygiene.
Personal Protective Equipment

- Full face shield
- Clean and dry cryogenic gloves for handling cold items or thick leather gloves to protect against splashes and for handling cold items
- Gloves should be loose fitting and easy to slip off in the event of a spill which enters the glove);
- Sturdy closed footwear that can be removed easily in the event of a spill;
- Clothing that covers the top of the footwear should be worn (on the outside of footwear)
- Sturdy vinyl apron
• Read labels and MSDS before first use.
• Store upright in ventilated area away from traffic.
• Protect cylinders from damage and heat.
• Wear substantial shoes, safety glasses and gloves when handling cylinders.
• Always move cylinders using an appropriate trolley.
• When moving cylinders take care not to turn the control valve.
• Open valves and regulators slowly
• Only use the suppliers valve key to open and close cylinders
• If a cylinder is damaged contact the supplier immediately to arrange its return.