Gas and Liquid Nitrogen Handling

Fluid Science Division, UWA Centre for Energy

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1 Introduction

This document provides an overview for safe handling of high-pressure gas and liquid nitrogen specific to the laboratories of the Fluid Science Division. It is additional information to supplementing the relevant UWA Occupational Health and Safety policies. This material is intended to be accompanied by personal instructionand training from a staff member of the group, followed by a practical demonstration of competency.

If you have a saftey concern for a particular experiment or there is a safety incident contact the relevant staff member immediately. If they are unavailable firstly contact Paul Stanwix, or else Eric May or Mike Johns.

Remember, if in doubt always seek advice!

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2 High Pressure Gas Cylinder

2.1 Hazards

Gas cylinders present a number of hazards in the laboratory environment, including:

- High pressure
- Asphyxiation
- Flammable
- Toxic
- Handling

It is essential to familiarise yourself with the Material Safety Data Sheet (MSDS) and handling procedures for all relevant gases (available in the lab).

Some of the main gas hazard classifications are shown below:

Class Diamonds	Australian Standards Definition	Cylinder Colour Identification*
 Toxic	A gas that is known to be a) toxic or corrosive to humans as to pose a hazard to health; or b) presumed to be toxic or corrosive to humans because it has an LC 50 value equal to or less than 5000 ml/m³ (ppm).	Hues of Yellow
 Flammable	A gas which will burn in air at a pressure of 101.3 kPa absolute.	Hues of Red
 Oxidising	A gas which gives up oxygen readily, removes hydrogen from a compound, or readily accepts electrons.	Hues of Black, White, or bright Blue
 Non-flammable, non-toxic	A gas which is non-flammable, non-toxic, non-oxidising, and is resistant to chemical action under normally encountered conditions.	Hues of Brown, Green or dark Blue

2.2 Precautions

2.2.1 Protective Clothing

- Safety glasses
- Covered shoes must always be worn in the lab

2.2.2 Air Monitoring

Laboratories may have air monitors installed, to warn of, for example, flammable gas build-up or reduced oxygen levels. Be aware of the light and sound warnings:

- Blue light – warning
- Red light – evacuate lab immediately
- Siren

2.3 Gas Storage

- Cylinders should not be allowed to drop or be struck violently.
- Cylinders must be properly secured at all times. Cylinders are to be secured to a wall, cylinder truck, cylinder rack, or post through the use of secure hooks and chains.
- Only one cylinder per restraint device. Do not chain multiple cylinders in one cylinder bay or restraint device.
- Cylinders should be stored in a well-ventilated area away from flames, sparks, or any source of heat or ignition. Keep cylinders away from electrical circuits.
- Flammable gas cylinders should not be stored with oxygen or nitrous oxide cylinders.
- Safety caps (where available) should be kept on the cylinders at all times when the cylinder is not in use.
- The number of cylinders in a lab must be minimised.
- Empty cylinders should not be stored in the lab, they should be returned to the central cylinder facility ASAP.
- Cylinders that are not in use for a prolonged period should be stored in central facilities.
- Cylinders can be stored outdoors, however they should be protected from the ground to prevent bottom corrosion. Cylinders should be stored so they are protected from the direct rays of the sun.

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2.4 Gas Handling

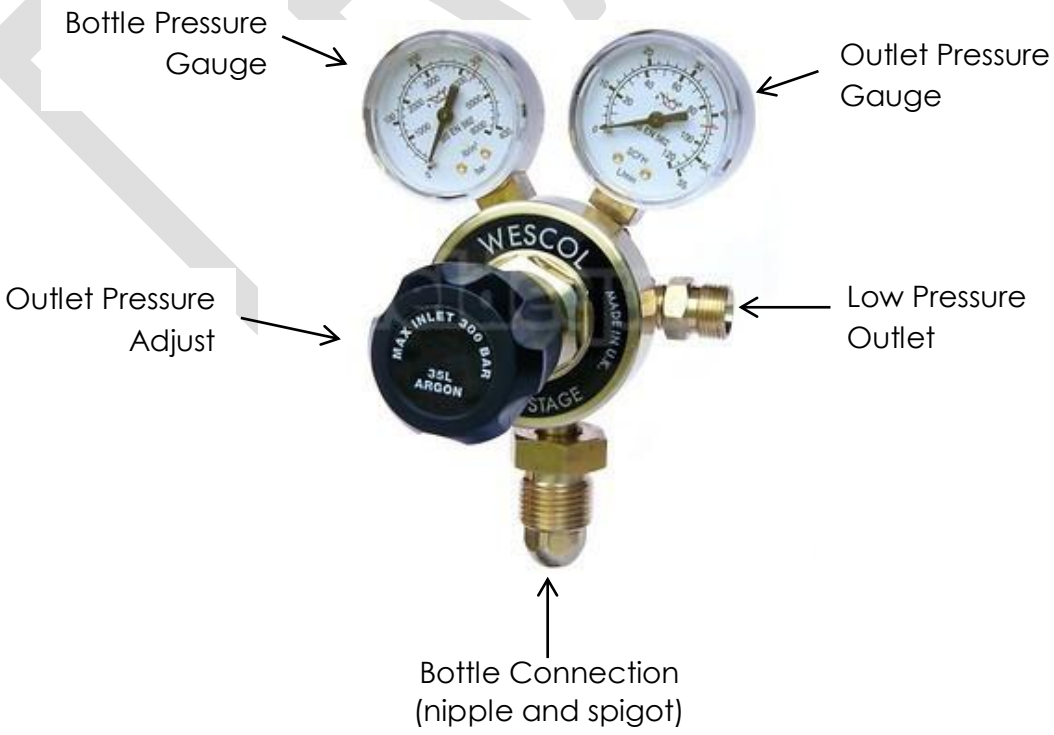
2.4.1 Transport

- Cylinders should be transported with safety caps where available. A cylinder's cap should be screwed all the way down on the cylinder's neck ring and should fit securely.
- Do not lift cylinders by the safety cap. The cap is for valve protection only.
- Remove regulator attachments prior to transporting cylinders.
- Always use a cylinder cart to move compressed gas cylinders. Refrain from sliding, dragging or rolling cylinders on edge for prolonged distances.
- Only one cylinder should be handled (moved) at a time.
- When a cylinder is transported in a lift (still in the gas trolley) no-one is allowed to travel in the lift with the cylinder. Use the yellow chain to barricade the lift door to stop other entering the lift. If possible, one person should send and another should be waiting to receive the cylinder from the lift.

2.4.2 Regulators

In the lab we use two stage regulators for delivering low pressure gas from high pressure cylinders. Two stage regulators allow for constant pressure gas delivery regardless how the cylinder pressure changes (until the cylinder pressure is below the desired outlet pressure).

- The gauge next to the regulator gas outlet is the delivery pressure and is controlled by adjusting the regulator pressure with the large front knob. This should not change once set at the desired deliver pressure.
- The other gauge displays the bottle pressure. This value should go down slowly through use.



2.4.3 Use of Gas Cylinders

- All gas bottles require a specific nut and spigot. If the fittings don't fit DO NOT force them - seek advice.
- Do not permit oil or grease to come in contact with cylinders or their valves.
- Open cylinder valves SLOWLY and FULLY. Do not use a wrench to open or close a hand wheel type cylinder valve. If it cannot be operated by hand seek advice.

Non-flammable gasses have a clock-wise thread, flammable gasses have an anti-clock wise thread.

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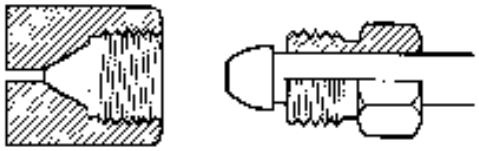
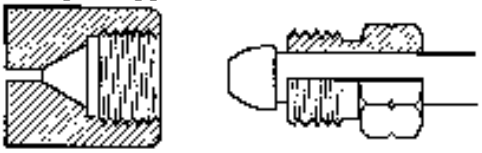
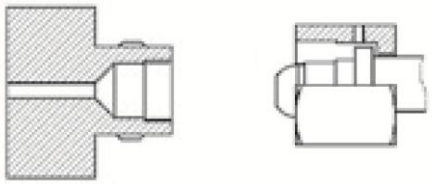
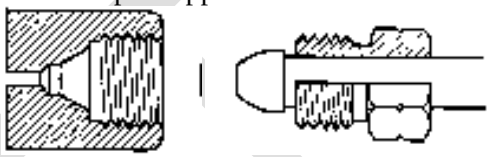
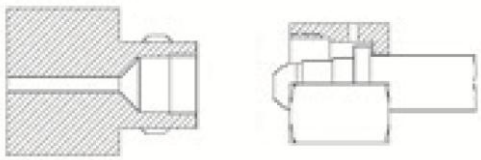
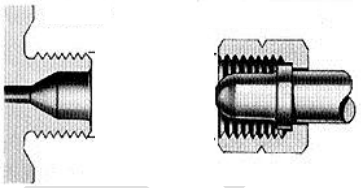
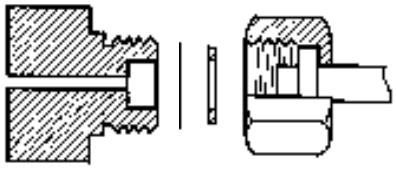
2.4.4 Cylinder Fittings Guide

Non-Flammable	Flammable
Right Hand (clockwise) Thread	Left Hand (anti-clockwise) Thread
Type 10. Helium, Argon bullet shaped nipple 	**Type 20. Hydrogen** bullet shaped nipple 
Type 50. Nitrogen bullet shaped nipple 	**Type 21 (CGA 510). Propane, Butanes** bullet shaped nipple 
Type 60. Air bullet shaped nipple 	**CGA 350. Methane, Ethane** 
Type 30. Carbon Dioxide Flat seat with washer 	

Note:

Nuts for flammable gasses have a notch on them (right) indicating that they are for flammable gasses and have a left hand (anti-clockwise) thread. Non-flammable gas nuts do not have this notch (left)

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2.4.5 Tubing, Fittings and Valves

Listed below are the main types of gas fittings are used in the lab for connecting gas lines and tubing. You should be able to identify each type and understand its use.

- Swagelok – a brand of compression type fitting, in which a ferrule is compressed onto a tube as a nut is tightened. This type of fitting is re-usable a limited number of times, until the tube and/or fitting becomes flared. Teflon tape is not used.
- Valco – another brand of compression fitting. Parts cannot be used interchangeably with Swagelok. Teflon tape is not used.
- VCR – a gasket type fitting made by Swagelok, which uses a disposable gasket. The fitting can be re-used with a new gasket each time.
- NPT – a tapered thread fitting that can be re-used.
- BSP – another type of threaded fitting that can be tapered or parallel.

Teflon tape should only be used on tapered threads. Parallel threads will incorporate a gasket, o-ring, spigot or specially machined mating surface.

When selecting tubing it is critical to consider the pressure and application. If you are unsure seek advice.

When tightening or loosening fittings it is important to use the correct size spanners, and preferably not an adjustable spanner. Two spanners should be use to apply the torque to the fitting component that rotates and the counter torque to the fitting that remains stationary. When tightening or loosening a fitting, the operator should be able to use one hand to manipulate both spanners. Before tightening or loosening use the right-hand rule (for normal threads) to identify which way the spanners should be turned to achieve the desired effect.

Valves are critical components of gas delivery systems. There are four major types in use by our laboratory: ball valves, needle valves, diagphram valves and automated valves. The first three are manually operated whilst the last type can be classified further as solenoid or pneumatically actuated. You should be able to identify all types, how to operate them, and how to identify whether they are in a closed or open condition. For manual valves, they should be closed tightly (but not over tight). When opened, they should generally be wound all the way to the fully open condition and then turned in the opposite direction about ¼ of a turn. They should be easily rotatable when open – if left at the fully open position they can stick and give the impression of being closed.

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2.4.6 Leak Testing

Whenever new gas lines or connections are made they should always be checked for leaks by a pressure test, inspection, and a gas detector if necessary. In particular, pressure dropping in a closed system indicates the presence of a leak. If you have trouble finding the leak**:**

- **Don't** give up and "live with it"
- **Don't** modify connections
- **Don't** over tighten
- **Don't** apply gasket compounds such as teflon tape out of place
- **Do** seek advice

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3 Liquid Nitrogen

3.1 Hazards

The two properties of liquid nitrogen that present potential hazards are:

- It is extremely cold. At atmospheric pressure, liquid nitrogen boils at -196 Celsius.
- Small amounts of liquid vaporise into large amounts of gas, roughly 700 times volume expansion.

3.1.1 Cold Burns

- Avoid direct contact with liquid nitrogen. Extremely low temperatures can freeze flesh very rapidly.
- When spilled on a surface the liquid tends to cover it completely and intimately, cooling a large area.
- The gas issuing from the liquid is also extremely cold. Delicate tissue, such as eyes, can be damaged by an exposure to cold gas alone
- Unprotected body parts contacting objects cooled by liquid nitrogen may stick fast. This may result in injuries by flesh being torn whilst attempt to withdraw from the object.

It is often stated that small splashes of liquid nitrogen will run off bare skin due to a vapour layer forming between the skin and the liquid. This must **never** be relied upon.

3.1.2 Over Pressure

Because liquid nitrogen boils rapidly users must ensure that it is never used in a closed system. 'Cold fingers' and similar devices have exploded when either an ice dam is formed within the apparatus or when inexperienced users created a closed system by shutting all valves.

3.1.3 Asphyxiation

Liquid Nitrogen rapidly vaporises to gas with about 700 times the liquid volume. By displacing air the gas may kill by asphyxiation. When the Oxygen concentration in air is sufficiently low, a person can become unconscious without any warning symptoms.

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3.2 Precautions

3.2.1 Protective Clothing

- When using or filling Liquid Nitrogen a face shield or safety glasses must be used.
- Always wear appropriate gloves when handling anything that is, or may have been, in immediate contact with Liquid Nitrogen.
- Use tongs to withdraw objects immersed in the liquid, and handle the object carefully.
- Do not put hands (even in the best gloves) into Liquid Nitrogen.
- Covered shoes must always be worn in the lab.

3.2.2 Equipment

- Only use equipment, supplies and materials that are designed for use with liquid nitrogen.
- Liquid nitrogen must only be stored and transported in a cryogenic Dewar.
- Ensure that liquid nitrogen is able to vent at all times and is not in a closed system. It may be necessary to punch holes in cryovial caps.
- Tape exposed glass parts to minimise the hazard of flying glass shards.
- DO NOT use "Thermos" flasks.

3.2.3 Air Monitoring

Laboratories may have air monitors installed, to warn of, for example, flammable gas build-up or reduced oxygen levels. Be aware of the light and sound warnings:

- Blue light – warning
- Red light – evacuate lab immediately
- Siren

3.2.4 Training

PhD students and above are allowed to fill a liquid nitrogen Dewars after they have had training. The training is to be conducted by John Moore (Physics Senior Technician).

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3.3 Handling of Liquid Nitrogen

Training in the use of liquid nitrogen in the Fluid Sciences lab is to be conducted by a staff member, covering techniques specific to the laboratory and experiment. This training is separate to the training provided for filling Dewars.

3.3.1 Transport

Tipping a liquid nitrogen Dewar or laying it on its side can cause spillage of liquid nitrogen. It may also damage the container and any materials stored in it. Large units are heavy enough to cause personal injury or damage to equipment if proper lifting and handling techniques are not used.

- Keep Dewars upright at all times.
- Transport Dewars that are not on wheels using a suitable trolley.
- Do not "walk", roll or drag Dewars across a floor.
- Do not transport liquid nitrogen containers in closed vehicles.

3.3.2 Use of Lifts

Never travel in a lift with a Dewar. There is a small risk that should a person remain in a closed lift for a prolonged time the venting gases may reduce the Oxygen level sufficiently to cause harm. To eliminate these risks the following practice should be followed when transporting Dewars:

- No one should accompany a Dewar in a lift.
- One person should send and another should be waiting to receive the Dewar from the lift if possible.
- Use the yellow chain to block entrance to the lift containing the liquid nitrogen to stop unauthorised entry into the lift.
- These rules apply for all lift use unless the Dewar is completely empty and warm.

3.3.3 Transfer of Liquid Nitrogen

Liquid nitrogen must only be transferred to or from a Dewar using the appropriate equipment. Training on the specific equipment and technique used for each experiment is to be obtained from the relevant staff member (not a fellow student).

3.3.4 Disposal

Never dispose of cryogenic liquids down the drain or on the lab floor. Ordinary materials may not be able to withstand cryogenic temperatures without failure. Laboratory plumbing is a common example.

Allow waste Liquid Nitrogen to evaporate naturally from the Dewar in the lab or if it needs to be emptied, consult a senior staff member.

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4 Competency Test

- Safely transport cylinder from storage to lab.
- Demonstrate attaching regulator. Decscribe/demonstrate use and explain purpose of each part of the regulator.
- Demonstrate tightening and opening a pre-prepared Swagelok fitting (1/4 or 1/8th inch)
- Identify valve types (3 manual and 2 automatic) and demonstrate opening and closing one of the manual types.
- Safely transport liquid nitrogen Dewar to lab.
- Demonstrate use of Dewar with experiment.

Item	**Check**
Safely transport cylinder from storage to lab.	
Demonstrate attaching regulator.	
Decscribe/demonstrate purpose and use of each part of the regulator.	
Descibe different gas fittings and their use.	
Demonstrate the tightening and opening of a Swagelok fitting.	
Identify valve types and demonstrate opening and closing of one type.	
Safely transport liquid nitrogen Dewar to lab.	
Demonstrate use of Dewar with experiment.	

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5 Revision

Name	Date	Comments
Brendan Graham	10/09/2012	Initial draft
Paul Stanwix	18/09/2012	Update format, add text
Eric May	19/09/2012	Add text on valves and fittings

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