University of Sussex

Safety Procedure and Guidance SPG-34-09 for the use of Gas cylinders, Compressed air and Cryogenic gases

1 GAS CYLINDERS

Legal Requirements

Pressure safety requirements are set down in the Pressure Systems Safety Regulations 2000. Detailed advice for implementing these regulations is given in the following publications:-

INDG-261 *Pressure systems- safety and you;* www.hse.gov.uk/pubns/indg261.pdf

Pressure Systems Safety Regulations, Approved Code of Practice, http://www.hse.gov.uk/pubns/priced/l122.pdf

BOC publication *Safe Under Pressure*, which gives detailed guidelines for the use of gases in cylinders, http://business.boc.com/online/Information/Data/Safe_under_pressure.pdf

Advice on interpretation of the above Codes of Practice and Guidance may be obtained from the University Safety Office.

Safety of Storage and Handling of Gas Cylinders

Comprehensive detailed safety advice is contained in the BOC Gases publication *Safe under pressure*.

Also see the BOC web site :- http://www.boc.ebcnet.co.uk/p/careWithCryogenics.pdf

When a cylinder becomes empty, the **cylinder valve MUST BE CLOSED** to prevent entry of moist air which would cause internal corrosion. Each standard cylinder weighs approximately 90 kg, so wear safety shoes with steel toe caps when handling them. Also wear **clean** gloves this allows you to "milk churn" cylinders along the floor from the secure store or use position to a trolley and not over great distances keeping them upright at all times. Never try to catch a falling cylinder. If a cylinder falls over, the main valve should only bend. If it did sheer off, the cylinder would only spin or move at 6 kph along the floor.

Acknowledgement: Written by M. Strong & T. Knapp incorporating extracts from other documents written by Peter Balance.
Reviewed by T Knapp/G Ward 2011

When transporting gas cylinders always remove the regulator and make sure the cylinder is placed in an upright cylinder trolley and is secure within the trolley, i.e. securing chains are tightly fastened or locking bar has wing nuts attached and screwed down, never bump down stairs. All trolleys used for transporting gas cylinders must have at least 3 wheels so they are stable and the user does not have to take the full weight of the cylinder. Cylinders may only be moved on a proper trolley, not with sack barrows, and the regulator valve must be taken off before they are moved.

Cylinders must be kept in a properly designed stand or chained to a bench in an upright position. The chain or strap must be tight enough so that the cylinder can not slide out if tipped. They must not be left free standing. When not in use the gas must be turned off at the cylinder valve, (do not remove the valve key from the cylinder). Where cylinders are issued with operating instructions, these must not be removed.

Spare cylinders must not be stored in the laboratory only those required for the purpose of the work should be in the laboratory or workshop.

Doors to the laboratory/workshop where gas cylinders are present must have a sign indicating that gas cylinders are present with an indication of the type of gas in use.

All areas where gas cylinders are in use must be suitably ventilated. Where there is a possibility of oxygen displacement and a risk of asphyxiation a low oxygen alarm must be installed, this should be determined by the risk assessment for the use of gas cylinders.

Cylinders should be stored in a well ventilated area or fireproof room external to the building. There must be a wall or partition giving at least a 3m vapour pathway between stored oxygen and fuel gas cylinders. This segregation applies to empty as well as full cylinders. (This separation does not apply to oxygen/acetylene cylinders **in pairs** which are **in use**.) Toxic and corrosive gases should be stored separately from all other gases. Containers should be clearly marked if empty or full.

The Main Hazards from Gas Cylinders

High Pressure - sudden explosive release of pressure or high pressure jet from small aperture.

Toxic gas - refer to COSHH assessment and data sheet.

Flammable or explosive gas.

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Asphyxiation - when used in unventilated or confined spaces.

Manual handling - normal sized cylinders weigh in the order of 90Kg.

There are three main types of gases:

- inert gases e.g. nitrogen, carbon dioxide	- these are not life supporting. Entry into a confined space where the inert gas has significantly reduced the oxygen concentration can cause rapid loss of consciousness and unless affected persons are rescued death may occur.
- fuel gases e.g. acetylene, hydrogen, propane	- these are highly flammable and explosive in air, even in low concentrations, if a source of ignition is present. - these are also not life supporting. Entry into a confined space where the gas has significantly reduced the oxygen concentration can cause rapid loss of consciousness and unless affected persons are rescued death may occur.
- oxygen	- supports combustion. If a cylinder leaks in a confined space or into clothing and an ignition source is present then the likelihood of a fire is greatly increased and the resultant fire will be far more intense.. Some materials are spontaneously flammable in oxygen enriched atmospheres. Oil, grease or organic material on the cylinder threads will react explosively; therefore, never use PTFE tape on threads.

Any use of gas cylinders must have an associated risk assessment with a safe system of work.

No work of any nature will be undertaken by Mechanical Workshop personnel on cylinders of pressurised gas, i.e. the making of take-off adapters, valve keys, or the loan of non-standard tools for opening cylinder valves.

NEVER approach or attempt to move a cylinder which has been in a fire (NB: Cylinders involved in a fire may explode): Evacuate the area and contact the fire brigade.

Cylinders which have developed stiff, locked or leaking valves should be returned immediately to the Store with a note of the fault attached for return to the supplier.

When opening the cylinder main spindle valve, only open the valve sufficiently to ensure an adequate supply of gas and never more than one turn. Do not remove the valve key, it may be needed to quickly shut off the gas.

Colour Coding of Cylinders

Gas cylinders are painted different colours according to the gas contained. Check the BOC web site for current colour coding

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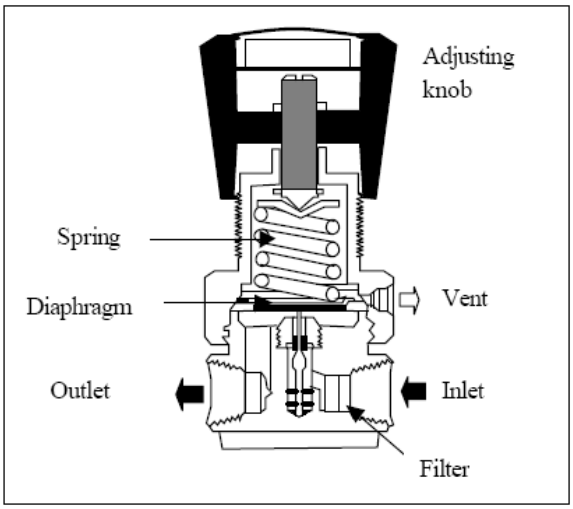
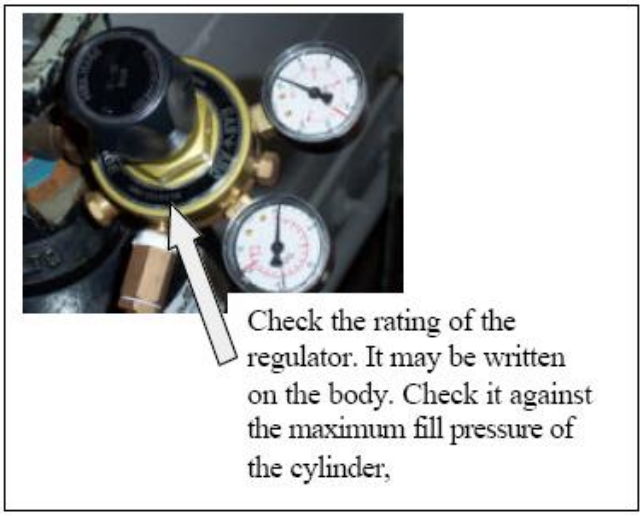
http://www.boconline.co.uk/health/gas_safety/identifying_gas_cylinders/industrial_cylinder_colours.asp

Do NOT rely on colour coding as an indicator of cylinder contents this must be used in conjunction with the cylinder contents label. If no label is present do not accept the cylinder.

Regulators

There are two basic types of regulator – single stage and two-stage regulators. The diagram below shows a single stage regulator in cross section.





Single stage regulators are cheaper to buy, but it is often difficult to maintain a steady outlet pressure - it tends to rise as the cylinder empties because there is less gas pressure exerted on the valve stem. Two stage regulators (which are of similar construction to two single-stage regulators in series) give a steadier outlet pressure, and a finer control over the outlet pressure. High pressure gas enters the regulator through the inlet into the high pressure chamber. The adjusting knob, when turned clockwise, compresses the spring and this exerts a force against the diaphragm. This pushes the valve stem open, releasing gas into the low pressure chamber. Equilibrium is reached when the spring force on the diaphragm is equal to the opposing force of the gas in the low pressure chamber. In a two stage regulator the first stage reduces the inlet pressure to a preset intermediate pressure – typically 25 to 35 bar, and then by adjusting the control knob the second stage reduces the intermediate pressure to the desired delivery pressure.

Cylinders must never be used without the correct pressure reducing regulator.

For cylinder gases a regulator life of 5 years will generally be quoted. A regulator will age irrespective of the amount of use it is put to. All regulators should be 'tagged' before dispatch with Serial No., Date of Manufacture and Expiry Date. This information should be kept recorded and regulators renewed by the expiry date.

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Make sure that the regulator can cope with the maximum pressure in the cylinder (this is marked on the cylinder label) and any pipework or tubing used is rated at the maximum deliverable regulator pressure.

All regulators are designated as to which gas they must be used with. They are designed with the internal components matched to the gas they are intended for to prevent corrosion, chemical reaction and deterioration of performance during the designed life time of the regulator. Ensure that stainless steel regulators are used for high purity and/or corrosive service
Regulators must **never** be used with a gas for which they are not intended.

PTFE tape must **not** be used on any gas connections. (Some cylinders may appear to have PTFE tape around the connector nut when supplied, do not be fooled, this is not PTFE tape it is an oil free tape to protect the nut and is not put inside the thread to form a seal.)

Note: Standard British cylinders and fittings for combustible gases have left hand threads. All others have right hand threads.

Regulators and their associated pressure gauges should never be tampered with or repairs attempted; if they leak or the pressure readings are suspect a replacement must be obtained, All gas equipment such as regulators, flashback arrestors and hoses must be replaced after five years of use. Regulators are date stamped and should be checked before use and at regular periods when in use to ensure they are within the safe operational time period.

Regulators have two jobs to do, calling for quite different qualities. They have to combine the strength necessary to control high pressures, with the delicacy and precision required to give accurate pressure readings. It follows that although they will stand a fair amount of rough treatment, reasonable care will ensure a longer life and more satisfactory operation. The following points will help in maintaining their good condition:

(a) If dust is suspected to be in the cylinder take off connection it should be removed by blowing out the threaded connection with a nitrogen line.
DO NOT 'CRACK OPEN' CYLINDER VALVE TO CLEAR THE OBSTRUCTION, BECAUSE SOME FLAMMABLE GASES MAY IGNITE.

(b) Before fitting a regulator always close the outlet valve by turning the pressure adjusting screw fully anticlockwise - otherwise the regulator may be damaged

(c) Always open cylinder and line valves gradually. If opened suddenly the abrupt compression will generate excessive heat, which may be enough to ignite the valve seat material, or damage the gauge or seat.

(d) When closing down, shut the cylinder valve then close the outlet valve by turning the pressure adjusting screw fully anticlockwise..

In the case of fuel gas supplies, cylinder manifolds or headers must be fully equipped with pressure regulators and proper **flashback arrestors**. When using oxygen with a fuel gas, both cylinders must

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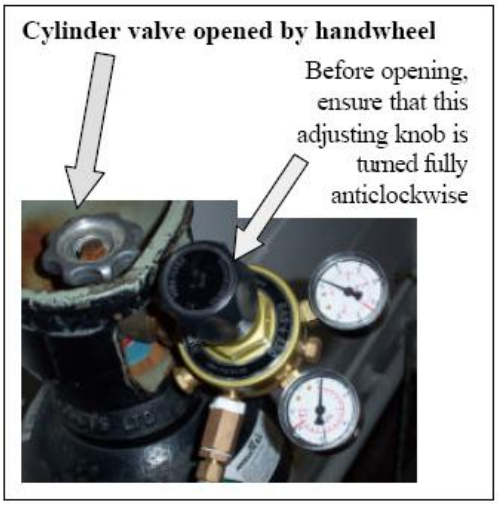
have flashback arrestors and hose check valves should be fitted next to the torch where the gases are mixed prior to combustion.



Dealing with a flashback incident - Failure to use the correct nozzle size or, more often, failure to set the correct gas pressure can result in a flashback or 'backfire' which, if no flashback arrestor is fitted, could travel into the cylinder where it may cause internal heating or even explosive decomposition of the acetylene! To deal with a flashback:

(a) close blowpipe/torch valves (oxygen first), then
(b) close both cylinder valves;
(c) check surface of acetylene cylinder with bare hand for local heating;
(d) if heating is detected, treat as though cylinder has been in a fire; activate the nearest break-glass call point, evacuate the area to 200 m. and call the emergency number 3333 notifying Security of the incident and request immediate attendance of the Fire and Rescue Service.
(e) if temperature does not rise, unwind pressure adjustment screws on both regulators;
(f) check nozzle of torch - if hot, plunge it into hot water to cool it;
(g) check that nozzle is undamaged.
(h) take flashback arrestors and regulators off and examine them for burns. If necessary replace them;
(i) carry out lighting procedure as recommended by supplier. If flashback occurs again, go through above safety procedure and, if necessary, replace torch and nozzle.

Hoses

Hoses must be of the correct thickness to withstand the required operating pressures. They must also be in good condition, and kept clear of possible damage by cuts, cracks and burns, and contact with oils, solvents, grease, etc. Blue hose must be used for oxygen and red for acetylene and other combustible gases. Hoses for arc welding and inert gases should be black.
The oxygen and fuel gas hoses must **never** be taped together.
All hoses must be secured with approved crimped metal clips. Suspected leakages should be tested with a brush and a 1% solution of 'Teepol HB7' (note: Teepol is a non oil based detergent, **do not use washing up liquid solution**), or use a propriety leak test solution available from gas suppliers.

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Keep hose lengths as short as possible. If the cylinder cannot be positioned near to the delivery point then the gas should be piped in compatible metal tubing to a suitable take-off point..

Special precautions for commonly used gases.

Note that with the exception of oxygen and air there is a risk of asphyxiation with all compressed gases should cylinders leak or otherwise discharge into poorly ventilated areas.

Hydrogen.

Flammability and explosion over a wide range of concentrations (4 – 75% in air) are the major hazards in using hydrogen. It should not be used near flames, sparks or sources of excessive heat. Tools and equipment should be spark and explosion proof. All hydrogen cylinders and lines should be earthed to discharge static.

Note that hydrogen cylinders must not be positioned, either for use or storage, near to other combustion-supporting gases such as oxygen.

Hydrogen has no smell and is lighter than air so will collect at the highest point in any enclosed space and pose a fire/explosion hazard.

Propane and Butane

Propane and butane, like acetylene, have a distinctive smell. A spark, a flame or hot metal may cause all these gases to ignite instantly. Propane or butane cylinders must be stored and used in the **upright** position or liquid gas may flow to the blowpipe or torch. In a fire a propane cylinder stored upright will vent. If stored on its side, liquid propane will be forced out of the safety valve and will ignite to cause a boiling liquid expanding vapour explosion (BLEVE). Propane cylinders on their sides in a fire may burst, again resulting in a BLEVE.

Oxygen

Oxygen is odourless and does not burn, but it accelerates combustion. Therefore, never allow your clothing to get saturated with oxygen! Oil and grease will ignite violently in the presence of oxygen which, if under pressure, can cause an explosion. Never wear oily clothes when using oxygen. Oxygen must NEVER be used in place of compressed air. **Grease** must NOT be allowed to come into contact with oxygen cylinders or connecting fittings. Threads for oxygen fittings must not be greased or wrapped with PTFE tape.

Acetylene

Acetylene forms explosive mixtures in concentrations of between 2% and 82% if ignited in air. It may explode under excessive pressure in the absence of air. To improve safety and stability, acetylene is supplied in cylinders dissolved in acetone, which is absorbed onto a solid packing material. Therefore, it is important that the cylinder is always **stored and used in an upright**

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position. It is also unsafe to use acetylene at a rate exceeding 20% of the cylinder contents each hour or acetone may boil off, thereby reducing the stability of the cylinder contents. To minimise the risk of flashback to the cylinder ALWAYS ensure an adequate flow of fuel gas is issuing from the blowpipe nozzle before lighting the gas.

Acetylene must not be delivered at a pressure greater than 0.6 bar (9 psi)

In the case of all combined acetylene and oxygen apparatus, **flashback arrestors** must be fitted to both the oxygen and the acetylene cylinders. In addition, hose check valves should be fitted next to the torch. It is advised that all such oxy-acetylene units are inspected annually, e.g. by an engineer of the British Oxygen Co. Some re-settable FBAs are available - a button pops up. If this happens, switch off the oxygen, then the acetylene.

Lighting-up and shutting down procedures for welding and cutting - 98% of flashbacks are due to failure to follow the correct torch lighting procedure which is as follows:

(a) use chart to determine correct pressures to be used for the nozzle size;
(b) purge 10 seconds with acetylene;
(c) purge 10 seconds with oxygen;
(d) light the acetylene - adjust to get a clear flame, then
(e) open oxygen valve and get a strong blue flame for welding.

For oxy-acetylene cutting, follow the manufacturer's torch lighting procedure. Normally this involves opening the acetylene valve and lighting. Then open the oxygen valve, followed by depressing the oxygen lever. The shut-down procedure is as follows:

(a) extinguish flame;
(b) close both cylinder valves;
(c) vent gases from hose (acetylene first) till gauges read zero; then
(d) close all valves and wind regulator control fully out.

Acetylene cylinders should not be stored inside building but in secure external compounds or outbuildings. As with other gas cylinders the smallest cylinder size required for the work should be used.

Additional guidance in the storage and use of acetylene has been provided in the **Health and Safety Executive note entitled, *Take care with Acetylene,*** *free download from:-* ***www.hse.gov.uk/pubns/indg327.pdf*.**
These notes describe the legal requirements concerning storage conditions and pipework systems permitted for acetylene facilities. They also indicate the very important requirement for an HSE approved type of **flashback arrestor.**

If in contact with certain metals or alloys, particularly of copper or silver, acetylene can form explosive compounds. Auxiliary equipment made of copper or any alloy of more than 70% copper must never be used.

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For remote work, take a small, e.g. 'Midipak' or 'Startapak', welding unit to the work location.

Sources of Heat or Ignition

DO NOT SMOKE, near cylinders or allow cylinders to come into contact with any **EXPOSED FLAME, ELECTRICAL APPARATUS OR LIVE WIRES**. Keep well clear of welding or cutting operations.

2 COMPRESSED AIR

Some labs and workshops are supplied with compressed air from a building local compressor these are normally in the order of 80-100psi.

Jets of compressed air are highly dangerous and should NEVER be pointed at other people (or oneself). Compressed air can cause skin damage.

Compressed air hose must be kept in good condition and anchored so that it cannot thrash around in the event of a breakage.

Compressed air should not be used to clean down machine tools or to remove grit or swarf. A vacuum cleaner or a brush are safer and avoid spreading foreign matter over surrounding equipment.

3 CRYOGENIC LIQUID & SOLID GASES

The most common in use at the university are liquid Helium (-269^{o} C), liquid nitrogen (-196^{o}C) and solid CO2 (-78^{o}C).

Hazards

Cold liquefied gases and solid carbon dioxide present a number of hazards.
Severe cold burns (frostbite) can result from mishandling, especially if the liquid is trapped in shoes or clothing. Brief exposure to extremely cold air produces some discomfort in breathing, longer term exposure can cause lung damage.

The evaporation of large quantities of liquid nitrogen/helium or the sublimation of large quantities of carbon dioxide in confined areas may result in displacement of oxygen and the risk of asphyxiation.

The cooling effect can cause structural damage. Structural steel may result in brittle fracture.
Spillage of liquid nitrogen may cause cracking in plastic insulation on electrical leads.

Because oxygen freezes at -183^{o}C oxygen from the air can condense on material cooled to liquid N or Liquid He temperatures this could pose a risk of combustion if this condensed liquid Oxygen comes into contact flammable material such as cloth or oil.

Precautions.

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Special techniques are needed to handle liquid hydrogen and helium. Instruction from a competent person must be received before attempting procedures for the first time.

The rules for filling dewars with liquefied nitrogen are on a notice at the Filling facility. You must follow the procedures indicated.

Dewars must not be left unattended whilst they are being filled.

Protective clothing MUST be worn when working with cryogenic materials
(a) Eye protection: as a minimum, safety spectacles with side shields must be worn whenever handling liquid nitrogen. A face shield to EN 166 must be worn where there is a risk of splashing the face or eyes, e.g. during filling operations. Models with brow guard and chin guard offer the best protection.
(b) Hand protection: For filling operations, loose fitting non-absorbent, insulated gloves to EN 511, or loose fitting leather gloves (for ease of removal in case of spillage) must be worn and coat sleeves should cover the ends of the gloves. Gauntlets are not recommended as liquid may run down inside them. These gloves will also protect the skin from contact with objects that have been cooled by liquid nitrogen. **Gloves are not intended to protect the hands against immersion in liquid nitrogen.**

(c) Foot protection: open toed shoes must not be worn.

(d) Clothing: as a minimum, a lab coat or overall should be worn. If boots are worn, then trousers should be worn outside of them, not tucked into them. A splash resistant apron will give added protection where dewars are being lifted or carried, or wherever there is a high risk of splashing, e.g. during filling operations

(e) It is advisable not to wear watches or hand jewellery when handling liquid gases in quantities.

Transporting dewars has a risk. Because of their construction the inner vessel is suspended by the neck of the vessel and this can be stressed by wheeling the dewer over rough ground, paving slabs with seems or rough concrete. Ensure vessels that have to be used outside of the building are fitted with large soft rubber or pneumatic tyres, avoid bumps.

Do NOT ride in the lift with a full or partially full dewar, if the power were to fail the liquid will slowly revert to gas and pose an asphyxiation risk, you should have two people present one at the

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floor you are dispatching the dewar from and one at the receiving floor. It maybe advisable to have a notice on the dewar to warn others not to enter the lift .

Wherever liquid or solid gases are used the area must be well ventilated or sufficiently large, to ensure that the oxygen concentration does not fall below 19.5% vol. Oxygen depletion monitors MUST be installed in areas where a number of dewers are located or where they are located in small spaces. **Because they are tightly sealed, cold rooms are particularly unsuitable as storage areas for liquid nitrogen and they must not be used for this purpose**.
Please contact the University Safety Office for further guidance.

Where pipework carrying cryogenic gases are installed it MUST be appropriately insulated and warning tape attached along the length. Where liquid nitrogen take-off points from a bulk supply tank are provided inside a building, whether for manual operation or for automatic filling of storage tanks, then oxygen monitoring must be provided at those points

Cryogenic Gas containers

(a) Liquefied gas containers must be handled carefully at all times.
(b) They must be protected from the weather, i.e. not left out of doors or in conditions favourable to the formation of an ice plug in the neck.
(c) Ice plugs can cause a 300 psig pressure build-up and an explosion. Such obstruction of the neck should be cleared with clean metal rods by an operator standing as far away as is practicable.
(d) Wide mouthed vessels should be used and when dewars are being purchased wide mouthed, all welded vessels with bursting discs must be chosen.
(e) Tight fitting stoppers or bungs must not be used on dewars or flasks containing liquid gases.
(f) Only use sample storage vials designed for use with liquid nitrogen. Vapour phase storage is recommended as the shrinkage and embrittlement of materials renders any sealing system ineffective and the relatively low surface tension of liquid nitrogen also makes it likely to seep into the vial leading to a potential explosion

First aid for cold burns

Do not remove clothing or material adherent (stuck) to person until thawed so it can be removed easily.
Skin; thaw slowly in lukewarm water approx 40-45^{o}C, **not** hot water.
Seek medical assistance.

Further Information.

BOC guidance Care with Cryogenics free download:-
www.boc.ebnet.co.uk/p/carewithcryogenics.pdf

Available from the suppliers such as BOC in the form of Data/safety Sheets

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