GUIDELINES FOR COMPRESSED GAS CYLINDERS MANAGEMENT

1.0 INTRODUCTION

Compressed gases can be flammable, toxic, corrosive, oxidizing, inert or some combination of these hazards. In addition to the chemical hazards, the amount of energy resulting from the compression of the gas makes a compressed gas cylinder a potential rocket. Therefore, CMU UTM is committed to comply with the rules and regulations enforced by the authorities to ensure the safety of all the staff, assets, and environment. **All UTM staff and students should adhere to the compulsory requirement before handling compressed gas**. The following information are general safety recommendation:

1.1 Know and understand gas properties: Properties, uses, and safety precautions is a must know elements before using any gas or gas mixture. Refer the Safety Data Sheet (SDS) for safety information on the gases that you will be used.
1.2 Check equipment: Leak test lines and equipment before they are used. Lines and equipment should be designed and maintained to handle full cylinder pressure. Materials of construction should be compatible with the gases being used.
1.3 Develop emergency plans: Be aware of potential hazards and develop plans to cover all possible emergencies.
1.4 Provide Personal Protective Protection (PPE): Wear suitable protective clothing, including gloves and face protection. Stay well informed of the potential hazards of the gases with which you are working.

2.0 PURPOSE

This guidance is intended to provide information on the hazards and risks associated with the use of compressed gas and the control measures which can be used. The contents of this guidance should be brought to the attention of all users of compressed gases. In many cases additional local information will be required to cover the circumstances in which compressed gas cylinder is being used within laboratories. This information should be supplemented by appropriate training and demonstration where specific tasks are undertaken.

3.0 SCOPE

This guideline is intended to specify requirement for the operation and handling, inspection and leak identified for compressed gas cylinder of sizes from 0.5 litre to 150 litre water capacity. For specific gas applications such as welding, diving, inerting, etc., there are additional requirements apply which are not covered in this guideline.

This guideline does not apply to:

i. Cylinders forming part of vehicle e.g NGV cylinder;
ii. Aerosol containers and gas catridges;
iii. Non-refillable cylinders;
iv. Fire extinguisher; and
v. LPG cylinders.

4.0 RESPONSIBILITY AND ACCOUNTABILITY

Storage area owner is responsible to display the safety signage as a form of communication to other people to prevent from any accident/ incident that may occur. All parties involved in the gas supply, acceptance

and/or use of the goods including staff, students, and other external parties, are responsible in ensuring the instructions of handling of compressed gas are followed according to the signage displayed. **Failure to follow this guideline is at your own risk.**

5.0 HAZARDS

Since gases are invisible their presence is not readily identifiable, but they do have the potential hazards towards a physical and health. A physical hazard arises when the use of a compressed gas in potentially dangerous (note: cryogenic liquids and cylinders are covered under cryogenic guideline). Common physical hazards of compressed gas cylinder include:

- Flammable Gases
- Oxidizing Gases
- Pyrophoric Gas
- High Pressure Hazard

Often those material will also present a Health Hazard, due to their toxicity. Health Hazards of compressed gases include:

- Corrosives Gases
- Toxic Gases
- Asphyxiation

5.1 Flammable Gases

A flammable gas is a gas that can ignite readily and burn rapidly or explosive. It can be extremely hazardous in the workplace; for example: if the percentage of flammable material in the air is between the minimum and maximum limits, the presence of a flame or a source of ignition is likely to lead to rapid combustion or explosion. If there is inadequate ventilation, flammable gases can travel considerable distance to a source of ignition and flash back to the source of the gas. Figure 1 shows a flammable pictogram.

Figure 1: Flammable pictogram

5.2 Oxidizing Gases

Gases that contain oxygen above than atmospheric concentration (23-25%) such as nitrogen oxides and halogen gases (chlorine and fluorine). These gases can react rapidly and violently with combustible materials and can lead to fires or explosions which are very hard to extinguish and can spread rapidly. Figure 2 show a oxidizing pictogram.

Figure 2: Oxidizing pictogram

5.3 High Pressure Hazard (Decompression)

Compressed gases are hazardous due to high pressures inside the cylinders. Even at a relatively low pressure, gas can flow rapidly from an open or leaking cylinder. For example, if unsecured cylinder is knocked over and the cylinder valve breaks the gas can escape at a high-speed resulting in severe injury and property damage.

5.4 Pyrophoric Gas

Some gases, for example non-metal hydrides (diborane, silane, phosphine) or metal carbonyls (nickel carbonyl) are hazardous because it will ignite and burn spontaneously in the air.

5.5 Corrosives

Gases that can burn and destroy body tissues on contact. It can also attack and corroded metals. Common corrosive gases include ammonia, hydrogen chloride, chlorine, and methylamine. Figure 3 show a corrosive pictogram.

Figure 3: Corrosive pictogram

5.6 Poison (Toxic) Gases

Gases that have the potential to cause adverse health effects depending on the specific gas, its concentration, the length of exposure, and the route of exposure (inhalation, eye, or skin contact). Exposure to this type of gas may lead to illnesses, severe respiratory distress, respiratory muscle dysfunction, or immediate death. Figure 4 show a toxic pictogram.

Figure 4: Toxic pictogram

5.7 Asphyxiation Hazard

Inert gas such as argon, neon, helium, or nitrogen are hazardous because it can displace oxygen in air and may lead to suffocation. If the oxygen level falls too low, individuals in the affected area can lose consciousness or die from asphyxiation.

6.0 REQUIREMENT

6.1 Risk Assessment

It is particularly important that a risk assessment is completed for areas storing, quantities of compressed gas that present a significant risk of asphyxiation e.g., in the event of a leakage or the release of cylinder contents in the event of a valve failure.

The process for completing a risk assessment for the handling and use of compressed gas follows the same general rules for HIRARC.

- HI – Hazard Identification
- RA – Risk Assessment
- RC – Risk Control

The remaining sections below will help you to identify the hazards and determine the relevant control measures needed.

6.2 First Aid

Where inhalation has occurred, the victim (who may be unconscious) should be removed to a well-ventilated area. Rescuers should not put themselves at risk - a contaminated area should not be entered unless considered safe. Breathing apparatus may be required but should only be used by trained personnel. The person should be kept warm and rested whilst medical attention is obtained. If breathing has stopped then resuscitation should be commenced by a trained first aider.

6.3 PPE

All personnel involved in gas cylinder handling and storage must be provided with appropriate PPE. Selecting the right PPE for each specific job task that involves gas cylinder is essential. The PPE shall be selected based on risk assessment that includes consulting the SDS for each of the gases using in the area.

If determined by a risk assessment an inhalation risk exists, staff should wear an air-supplied mask that meets the requirements. The required PPE outlined in the standard and included some key considerations when deciding on what to use been listed below. Figure 5 shows a full PPE.

6.3.1 Hands

Protective gloves should be worn when handling cylinders gas. Types of gloves to use (PVS gloves, insulating gloves etc.) will be based on the type of gases at the worksite and how they are being used. Working gloves should protect hands from abrasions, cuts, tears, punctures, and anti-slippery while transferring or moving cylinders.

Eye protection

Hand protection

Safety boot

Respirator

Figure 5: Example of Full PPE

6.3.2 Face

Personnel who are handling a compressed gas cylinder should wear eye protection because it can cause eye damage if released suddenly from a cylinder. An uncontrolled release of compressed gas can dislodge metal shavings and create other dangerous projectiles. Check the impact resistance of the eyewear before deciding.

Handling of toxic or corrosive gases such as chlorine or ammonia, it should be a chemical goggles and respirator that dangerous gases cannot penetrate. Always refer recommendation from SDS to ensure that the eye guards, goggles, face shield or respirator being used are suitable with the gas. Ensure the eyewear and respirator fits each of your workers properly, as loose-fitting goggles can cause accidents through slippage or cause workers to take them off prematurely.

6.3.3 Body

The standard recommends wearing protective clothing such as overalls, when moving or handling gas cylinders.

6.3.4 Feet

Cylinder gases are heavy and can cause many fractures and other serious injuries to feet and toes. Personnel who are handling a gas cylinder should always be wearing protective footwear.

When not in use, all PPE should be stored in an appropriate manner (e.g., visors on wall mounted hooks) to ensure that it does not become damaged or contaminated.

6.4 Cylinder

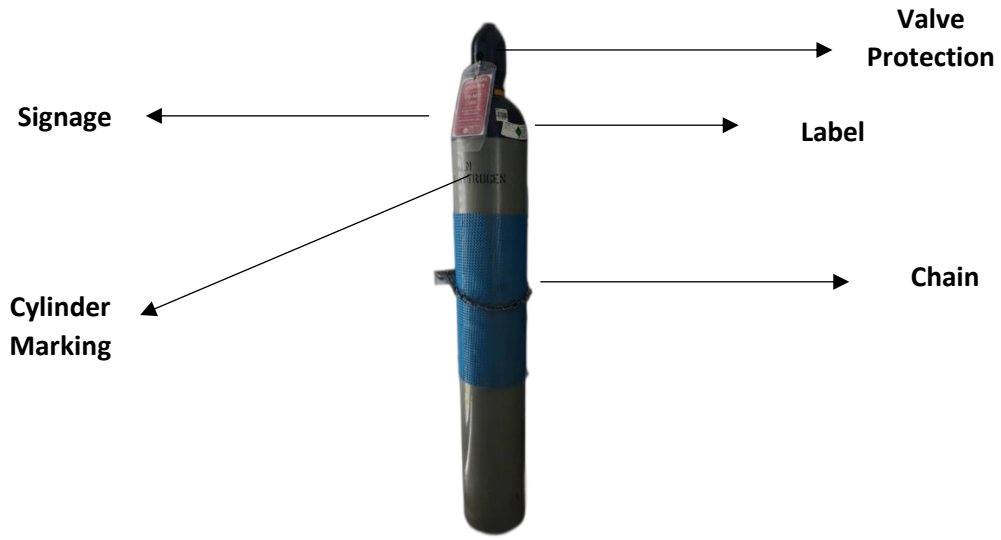


Figure 6: Compressed gas cylinder

6.5 Label

The cylinder labels are the primary means for identifying the contents of a gas cylinder, nature and hazards associated with the gas contained in the cylinder.

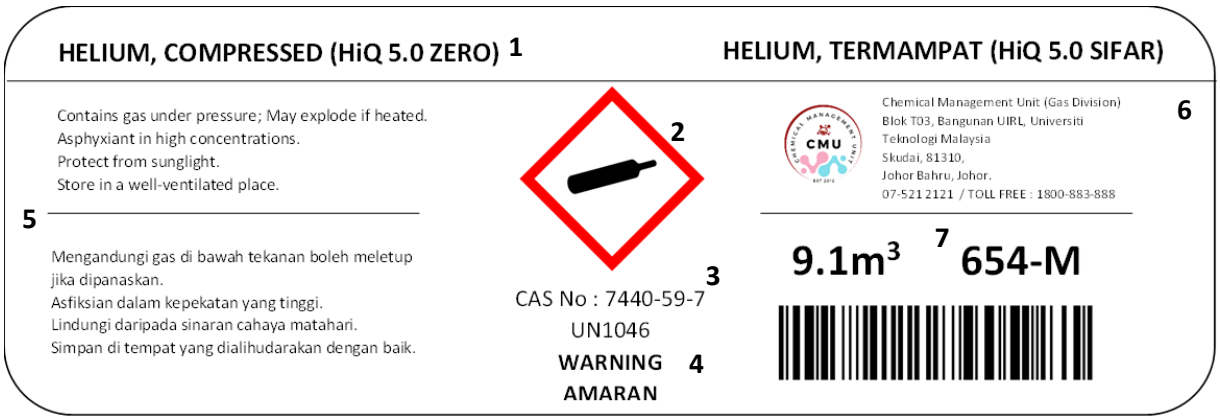


Figure 7: Label

Information display on the label: (1) Gas name and grade (2) Dangerous good classification – pictogram (3) United Nation numbering system for handling, transport and storage / Cas No. (4) Caution – indicated major hazard (5) General safety information (refer to SDS) (6) Manufacturer address and contact no. (7) Cylinder Size

Do not use a gas cylinder if the label is missing or illegible. Please contact a supplier to return or for a satisfactory replacement.

6.6 Regulator

Regulators are designed to be fitted directly to the cylinder valve. No other fittings, connections or lubricants shall valve used to connect a regulator to a gas cylinder valve. Regulators for flammable gasses are left hand treaded and have a notch cut out of faces on the securing nut to distinguish them from non-flammable gas regulator. Please refer figure 8 for regulator components:

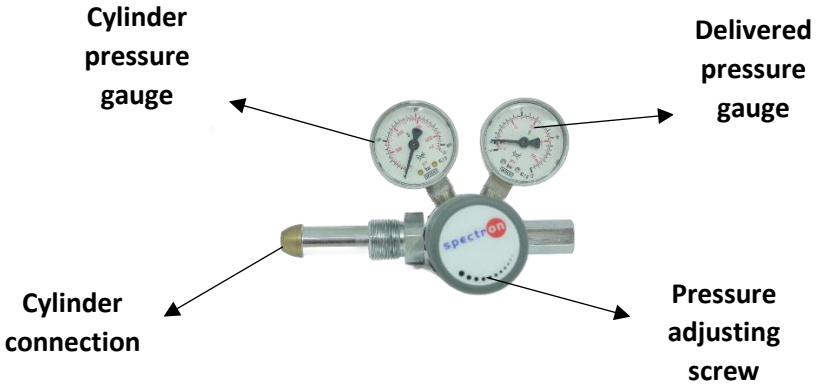


Figure 8: Regulator

Check regulator condition before installation or use. Please do not use damage or unsafe regulator.

6.7 Valve Protection

A valve guard also known as a valve protector or valve cover, is a protective device or enclosure designed to shield a valve from physical damage, environmental elements, and potential tampering. These guards are commonly used in industrial setting, particularly in facilities where valve is exposed to harsh conditions, high traffic areas or where accidental contact could occur. The following methods are common:

Figure 9: Valve guard

6.7.1 A valve guard – a device that is securely fixed around the valve but stands higher than the valve hand wheel. They can be of cast or welded construction or made from non-metallic

moulded plastics. They can be attached to either the cylinder shoulder, the cylinder neck (with a Cri-clip), or in some cases, the base of the valve. It does not need to be removed for access to the valve.

Figure 10: Valve shroud

6.7.2 A valve shroud – a type of valve guard but which is an integral part of a welded cylinder or pressure drum, most seen on LPG or refrigerant gas service.

Figure 11: Valve protection cap

6.7.3 A valve protection cap – a cover that is securely fixed over the valve during handling, transport and storage which is removed for access to the valve. It is designed not to contact the valve or the hand wheel.

7.0 PROCEDURE

This section will be discussed on overall process of handling cylinder gas procedure. Please refer Figure 12 for overall process flow.

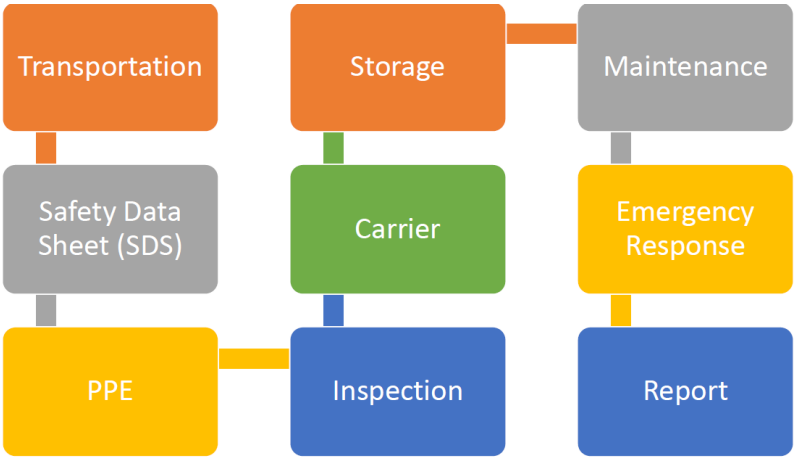


Figure 12: **Overall process flow for cylinder gas procedure**

7.1 Transportation

This section should be read in conjunction with any rules and regulation in Malaysia which set out the requirements for things such as load segregation, documentation, placarding, and load security.

Cylinder should be secured when being transported. Example of preferred methods include:

a) Cylinder(s) suitably supported in bins, racks, or suitably approved transportation devices; or
b) Cylinder in customised supporting 'cradle' or chocks that are designed to prevent the cylinder(s) from rolling,
c) Cylinder(s) restrained in the upright attitude by way of tie-down straps or ropes.

Please take note that, **Do Not** transport gas cylinder in the passenger compartment of any vehicle due to the difficulty of providing appropriate load restraint. Transporting gas cylinder inside the driver or passenger compartment of passenger cars is extremely dangerous and could cause an explosion, fire, exposure to toxic gas, or asphyxiation.

It is advisable to contact a cylinder gas supplier for transport a cylinder gas from your area to others if required.

7.2 Inspection and maintenance of cylinder gas

Inspecting and maintaining a gas cylinder is an important safety measure to ensure that it is in a good condition and suitable for use. Before handling an inspection or maintenance, ensure all the safety aspect has been followed such as wear PPE, read the SDS and inspection area is in a good ventilation. Here are some general guidelines for the inspection or maintenance of gas cylinders and piping:

7.2.1 Safety precaution

- Please read SDS for specific gas before handling a cylinder.
- Wear appropriate PPE, please refer section 6.3.
- Ensure good ventilation in the area where you are inspecting the cylinder.

7.2.2 Examine the cylinder exterior:

- Look for signs of physical damage, such as dents, cracks, or bulges. If you find any, do not use the cylinder, and report it to the supplier.

7.2.3 Check the valve:

- Ensure that the valve is tightly closed. If it is loose or leaking, do not use the cylinder.
- Examine the valve for signs of corrosion or damage. Report any issues to the supplier.

7.2.4 Check the pressure relief device:

- Ensure that the pressure relief device (safety valve) is intact and not tampered with. It should not be painted over or obstructed.

7.2.5 Inspect the labelling:

- Verify that the cylinder is properly labelled with the correct gas type, pressure ratings, and any other relevant information. Refer to section 6.5. If the label is missing or damaged, do not use the cylinder.

7.2.6 Check for expiration date:

- Some cylinders have an expiration date or re-qualification date stamped on them. Ensure the cylinder is within its valid period. If it's expired, do not use it. Please refer to your supplier for cylinder validation period.

7.2.7 Check for leakage:

- Close the valve tightly and listen for any hissing sounds, which may indicate a leak or if you hear a leak, do not use the cylinder.
- Use a brush or spray bottle to apply the soapy water solution to the suspected areas. This includes connections, joints, valve, and hoses.

7.2.8 House keeping

- Keep pipes clean from debris and contaminants, as they can cause corrosion and blockages. Ensure the storage area are clean from any fuel.

Remember, specific maintenance procedures may vary depending on the type of cylinders and piping, the materials used, and the substances being transported. Always refer to the manufacturer's guidelines and industry best practices for detailed instructions. Additionally, comply with relevant safety regulations and standards.

If you are unsure about the condition of a gas cylinder, or if you suspect any issues, it is best to contact a professional or your gas supplier for further guidance. Safety should always be the top priority when handling gas cylinders.

7.3 Carrier of cylinder gas

If you need to transport a gas cylinder, it is important to do so safely to prevent any leaks or accidents. Table 1 below shows some general guidelines for carrying a gas cylinder:

Table 1: Do and do not do during transport cylinder gas.

Do's	Don't
Use mechanical aids (ramps, trolley, forklifts, scissor lifts)	Bear-hug cylinders to affect a lift
Remove any connected equipment and refit any supplied valve protection	Drop a cylinder as a method of transfer
Ensure cylinders are properly restrained to mechanical lifting/handling device	Edge-roll more than one cylinder at time
Wear proper PPE (please refer SDS)	Attempt to catch or restrain a falling cylinder
Note environment conditions prior to handling cylinders	
Park the mechanical aids near to the cylinder gas	
No person is to travel in the lift with the gas cylinder	

Figure below is an example of mechanical ramps for transport cylinder gas. Note that, these mechanical ramps can only be used for nearby area only.

Figure 13: Forklift

Figure 14: Trolley

7.4 Installation of regulator

1.Inspect cylinder valve outlet from any damage

2.Open valve outlet sealed

3. Inspect cylinder valve outlet for contamination. Momentarily open and close cylinder valve to clear any contamination that may be present. Do not vent the valve if handling Toxic or Poison gasses. Avoid doing this practice with Hydrogen, it may explode.

4.Position regulator

5.Attach regulator to cylinder valve

6.Use wrench to securely tighten regulator. Secure regulator tight enough not to leak.

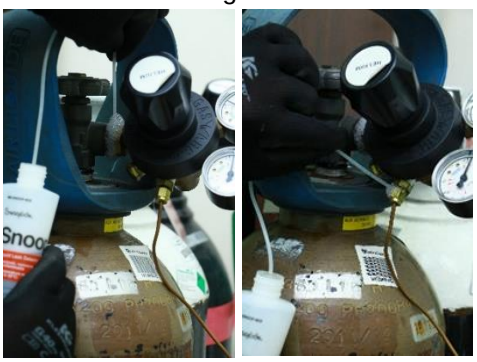
Note: No Teflon tape in connection. Bits of Teflon tape can get blown into the regulator causing a leak, value malfunction or erroneous reading.

7. Ensure regulator pressure adjusting screw is closed.

8. Connect hose

9. Open the cylinder valve slowly until pressure gauge is fully pressurized.

Note: Never stand in front or behind a regulator when opening a cylinder valve. Always stand so that the cylinder is between personnel and regulator.



10. Spray or apply the soapy water solution onto the area you want to test, such as a joint or fitting, and watch for bubbles. The soap solution will bubble if there is a gas leak or other fault in the line.

11.Open regulator pressure adjusting screw to the desired pressure.

7.5 Storage of cylinder gas

Take the following precautions to prevent injuries caused by asphyxiation, fire, explosion, high pressure, and improper handling of compressed gas. This following condition should be followed:

7.5.1 Storage area

i. is a designated area:
ii. is in a dry, cool, well-ventilated, secure area protected from the weather and away from combustible materials:
iii. provide adequate access for cylinder handling:
iv. should never expose cylinder to corrosive materials such as ice melting compounds:
v. should never permit smoking or open flames in oxidizer or flammable gas storage areas:
vi. only trained personnel shall enter the storage area:
vii. safety signage is mandatory:
viii. monitor the atmosphere in areas where gases may vent and collect:
ix. should away from heavily travelled areas and emergency exits:

7.5.2 At rest/ in operation condition

i. Store cylinder upright with valve outlet seals and valve protection caps in place:
ii. Secure cylinder when in storage, transit, or use
iii. If cylinder gas in use, (cylinder connected to a regulator) compressed gas cylinder must be individually secured to a stable surface like a wall or laboratory bench.
iv. Within the storage area, oxidizing gases should be stored at 3 – 6 meters away from flammable gases. 30 minutes fire-rated wall can also be used for separation. The wall must be minimum of 1 meter higher than the tallest cylinder.
v. Full and empty cylinder should be kept separately, and according to its hazard classes (refer to SDS)
vi. The size and number of gas cylinders in use or storage should be kept as small as practicable:
vii. Use a first-in, first-out (FIFO) inventory system to prevent full containers from being stored for long periods of time:
viii. Label each of the cylinder in store
ix. In case of flammable or toxic gases, is not in a person's work area and the quantities stored meet the required separation distances from areas of high and low intensity land use (note that use of such gases)

7.6 Emergency

7.6.1 Pre-planning

Despite adherence to cylinder safety practices, accidents involving gases may occur. The amount of damage sustained by personnel and property from these accidents is greatly influenced by the quality of the emergency plan. Users of compressed gases cylinders must be familiar with necessary safety precautions. Risk assessment for using compressed gases must include a discussion of possible accident scenarios, appropriate employee responses and should consider the following factors.

- The nature of the operation (experimental design, equipment used and type of injury that could occur).

- The potential location of a release or spill (e.g., outdoors versus indoors, in a room, corridor or storage area, on a table, in a hood, or on the floor).
- The quantities of material that might be released and the type of containment (i.e., compressed gas tank size, manifold systems, etc.).
- The chemical and physical properties of the compressed gas (e.g., its physical state, vapor pressure and air or water reactivity).
- The hazardous properties of the compressed gas (e.g., its toxicity, corrosively and flammability).
- The availability and locations of emergency supplies and equipment.

Plan for these emergencies by developing an Emergency Action Plan that identifies building evacuation routes, emergency telephone numbers, chemical containment procedures, fire extinguisher usage, etc.

7.6.2 Minor Leaks

Occasionally, a gas cylinder or one of its component parts may develop a leak. Most of these leaks occur at the top of the cylinder. In areas such as the valve threads, pressure safety device, valve stem, or the valve outlet. To correct minor leaks:

- For non-toxic gases, verify suspected leaks using a gas detector or soapy water solution (a flame should not be used for detection). If the leak cannot be stopped by tightening a valve gland or packing nut, notify supervisor or OSHE. **Do not** try to fix a leak on a toxic or highly toxic gas cylinder, instead initiate emergency action procedures.
- For flammable (non-toxic), inert or oxidizing gases (non-toxic), move the cylinder to an isolated, well-ventilated area (within or next to fume hood), away from combustible materials.
- For corrosive and toxic gas leaks, immediately contact OSHE or supplier for leak remediation or cylinder removal. Leave the room until supplier or professional corrects the leak or removes the cylinder from the lab. **Do not** remove a leaking toxic gas cylinder from the ventilated cabinet.

7.6.3 Major

In the event of a large gas release or if an accident takes place, activate the following emergency procedures:

i. Evacuate the area, securing entrances and providing assistance to others on the way out.

ii. Activate building alarms.

iii. Immediately call UTM Security Division and report to OSHE, and emergency response team (ERT).

iv. Provide ERT with details of the problem upon their arrival. The ERT will respond to all chemical emergencies.

8.0 REFERENCES

8.1 Occupational Safety and Health (Use and Standard of Exposure Chemical Hazardous to Health) Regulations 2000 (USECHH Regulations)
8.2 Occupational Safety and Health (Classification, Labeling and Safety Data Sheet of Hazardous Chemicals) Regulations 2013 (CLASS Regulations)
8.3 Occupations Safety and Health Act 1994 (Act 514)
8.4 Factories and Machinery Act 1967 (Act 139)
8.5 Safety Guidelines for Gas Cylinders (Construction, Operation and Maintenance) 2021, DOSH
8.6 The OSHA Respiratory Protection Standard ("the Standard"; 29 CFR 1910.134)
8.7 Guidelines for gas cylinder safety by BOC a member of the Linde group
8.8 Standard operating procedure (SOP) compressed gas cylinder from Eastern Washington University
8.9 Guidelines on storage of hazardous chemicals – a guide for safe warehousing of package hazardous chemicals by DOSH 2005
8.10 Gas cylinder safety guidelines by Environment Health and Safety, IOWA State University, 2019

9.0 GENERAL/ AMENDMENT

Issue No.	Review No.	Amendment Details	Effective Date
1	1/2023	Revision of Guideline for Compressed Gas and combination with Guidelines to Receive Chemical & Gas from Industry (CMC/SOP/10)	01/12/2023

Contact Details Chemical Management Unit (CMU)
University Laboratory Management Centre (PPMU)
Building T03 University Industry Research Lab (UIRL)
81310 UTM Skudai, Johor.
✉ : cmcutm@utm.my / gas.cmu@utm.my