

Storage and Handling of Gas Cylinders Guideline

Section 1 - Purpose and Scope

(1) This Guideline presents key information available on gas cylinder safety applicable to The University of Queensland's (UQ) work environment and is applicable to all UQ workers including contract workers who deliver and work with compressed gas cylinders at UQ.

(2) UQ is legally obliged under the <u>Work Health and Safety Regulation 2011</u> (<u>WHS Regulation</u>) to implement appropriate control measures in the workplace if it is not reasonably practicable to eliminate a health and safety risk.

(3) Compressed gases stored in portable cylinders are hazardous, and the risk to people and property must be minimised by correct storage, handling and usage. The use of portable compressed gas storage is very common at UQ and <u>AS 4332</u> 'The storage and handling of gases in cylinders', Workplace Health and Safety Queensland, as well as industry guides, detail correct procedures to ensure gas cylinder safety and provides practical guidance to achieving the standards of health, safety and wellbeing required under the <u>WHS Regulation</u>.

(4) This Guideline details the hazards of gas cylinders, along with the correct storage, handling and usage requirements to ensure people and property are not put at risk. The information given is based on minor storage compressed gas quantities that should apply to most areas of UQ.

Section 2 - Types of Gases, Cylinders and Regulators

Types of Gases

(5) There are three types of gases commonly supplied and used at UQ:

- a. Compressed gases nitrogen, oxygen, air, carbon dioxide, helium.
- b. Liquefied gases liquified petroleum gas (LPG), liquefied nitrous oxide.
- c. Dissolved gases acetylene.

(6) Cryogenic vapour could also be considered as a gas but is not included in this Guideline. Refer to the <u>Working</u> <u>Safely with Liquid Nitrogen and Dry Ice Guideline</u> for information on vapour from cryogens.

(7) The <u>linked table shows the four main classes of gases</u>. Gases can also have corrosive properties, e.g. ammonia and the class of gas defines its physical properties and transport requirements. However, it is also important for considering storage and handling/usage requirements.

Identification and Labelling of Cylinders

(8) Users should be familiar with the identification, markings and labelling of cylinders and they must not be modified.

- (9) Gas cylinders are required to be labelled with the following (also refer to Figure 1 and 2, linked below):
 - a. Class label and any subsidiary risk labels.
 - b. The proper shipping name.

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c. A four-digit United Nations (UN) number.

d. Manufacturer/importer's name.

Figure 1 - Cylinders label example

Figure 2 - Labels vary in shape, size and their positioning on cylinders and packs

(10) In general, there are three types of gas cylinders:

- a. High pressure cylinders come in a variety of sizes, see Figure 3. Some examples of gases supplied in high pressure cylinders include nitrogen, helium, hydrogen, oxygen and carbon dioxide.
- b. Low pressure cylinders come in a variety of sizes, see Figure 4. Some examples of gases supplied in low pressure cylinder are LPG and refrigerant gases.
- c. Acetylene cylinders aggregate filled, and acetylene is dissolved in acetone to get sufficient product into the cylinder. Acetylene is in a class of its own as the cylinder is filled with an aggregate material and dissolved in a liquid medium (acetone)

Figure 3 - High Pressure Cylinder sizes

Figure 4 - Other pressure sizes

Cylinder Valves and Regulators

(11) The gas cylinder value is the primary safety mechanism on a gas cylinder and must not be tampered with. It is a device used to contain the contents of the cylinder that is under pressure. Cylinder values are fitted with pressure relief values of different types (depending on the cylinder) to protect against catastrophic failure of the cylinder value. Figure 5 and Figure 6 show different types of cylinder values and pressure relief devices respectively.

Figure 5 - Typical cylinder valves

Figure 6 - Typical pressure relief devices fitted to cylinder valves. Bottom left - Integrated regulator type for 300 atms.

(12) The regulator is the next most important safety device to be fitted to a gas cylinder before operation/use. It allows for the high pressure of the cylinder contents to be brought down to a usable working pressure. Regulators come as single stage for short term applications and two stages for long term applications. Regulators are also constructed from different materials, mainly brass or stainless steel. The application will define the required regulator. If a person is unsure of which kind of regulator to use, consult the gas supplier. Regulators are designed to be fitted directly to the cylinder valve. No other fittings, connections or lubricants will be used to connect a regulator to a gas cylinder valve. Regulators for flammable gases are left hand threaded and have a notch cut out of faces on the securing nut to distinguish them from non-flammable gas regulators.

Section 3 - Hazards

(13) All compressed gases are hazardous due to the high pressures inside the cylinders. Risk assessments must be undertaken to identify hazards and the need for additional control measures. These are to be completed in <u>UQSafe</u>.

(14) The safety data sheet (SDS) should be consulted for the gas to determine:

- a. the chemical and physical hazards from each gas cylinder;
- b. appropriate safe storage and handling practices;
- c. the need for additional control measures;
- d. first aid measures;
- e. firefighting and emergency information.

Chemical

(15) Chemical hazards include:

- a. fire or explosion from the release of flammable gases near ignition sources (e.g., acetylene, hydrogen or LPG);
- b. spontaneous combustion from oxidising gases (e.g., oxygen or nitrous oxide);
- c. exposure of people and plant to toxic or corrosive gases (e.g., anhydrous ammonia);
- d. rupture of cylinders of time sensitive gases such as hydrogen fluoride and hydrogen bromide;
- e. asphyxiation from some non-toxic, non-flammable gases by displacement of oxygen (e.g. nitrogen, carbon dioxide and argon).

Physical

(16) Gas can be released deliberately by opening the cylinder valve, or accidentally from a failed or leaking valve. Even at a relatively low pressure, gas can flow rapidly from an open or leaking cylinder and may present a physical hazard.

(17) Compressed gas containers require regular maintenance and checks to ensure valve seal integrity. Damage to the valve in regulators resulting in seal failure and leakage of the gas can result in:

- a. low boiling point, cryogenic or liquefied gases may cause frostbite upon release;
- b. oxidising gases such as oxygen may increasing the propensity for things to burn and increase the intensity of a fire;
- c. gases denser than air (e.g., LPG, carbon dioxide) will tend to collect in low lying areas such as pits, depressions and basements increasing the risk of fire or explosion, asphyxiation, or exposure to toxic or corrosive gases;
- d. impact to the pressure vessel or structural failure from overuse or other defect, resulting in catastrophic failure with the release of shrapnel;
- e. a direct stream of high-pressure gas causing damage to the ears or eyes.

(18) Unsecured gas cylinders can fall with the resulting impact shearing off the valve stem. Most cylinder valves are designed to break at a point with an opening of approximately 75mm. This design limits the rate of gas release and reduces the velocity at which the cylinder will travel with a broken valve. However, they can still cause injury, especially smaller lighter cylinders that may 'rocket' into the air.

(19) Large gas cylinders can be heavy and awkward to move without proper equipment and training.

(20) The risk of musculoskeletal injury is higher for large and heavy cylinders (e.g. size G and F) but is also significant with smaller cylinders due to their low height and heavy weight, especially when full. Facility storage and access issues can also increase the risk of injury when moving cylinders.

(21) When moving gas cylinders, utilise risk management principles outlined in <u>Manual Tasks Risk Management</u> <u>Procedure</u> and <u>Guideline</u>. Ensure proper gas cylinder trolleys are utilised and consider optimal positioning of gas cylinders within labs, buildings and outdoor bulk gas storage to ensure safe and easy access to minimise risk of injury.

Section 4 - Risk Controls

(22) <u>Hierarchy of controls</u> should be followed with a preference for substitution, isolation or engineering controls above administrative controls or personal protective equipment (PPE). A combination of control measures may be used if a single control is not adequate to minimise the risk. Consider all possible control measures and assess which controls are reasonably practicable. Determining which controls are reasonably practicable includes assessing availability and suitability of control measures, regarding the level of risk. Cost may be relevant factor in determining reasonably practicable controls but should not be the primary consideration.

(23) Control measures may include the following as identified through the risk assessment process:

- a. Ventilation systems.
- b. Use of portable or fixed gas detection.
- c. Inspection and maintenance of equipment.
- d. Written procedures for safe handling.
- e. Emergency response plans and systems.
- f. PPE.

Ventilation Systems

(24) Well-designed and well-maintained ventilation systems remove gases from the workplace and reduce their hazards. The natural and dilution ventilation systems common across UQ reduce this risk, but the amount and type of ventilation needed depends on such things as the type of job, the kind and amount of gases used, and the size and layout of the work area.

(25) An assessment should reveal if existing ventilation controls (natural or mechanical) and other hazard control methods are adequate. They need to provide the requirements specified in section 4.3.2 of the <u>AS 4332 The storage</u> and handling of gases in cylinders.

(26) Some workplaces may need a complete system of hoods and ducts (local exhaust ventilation (LEV)) to provide acceptable ventilation. Others may require a single, well-placed exhaust fan. Storage facilities for particularly hazardous materials such as chlorine, may require an additional emergency ventilation system, or continuous monitoring with appropriate alarms (refer to 'Portable or Fixed Gas Detection' provisions). Other workplaces using small amounts of inert gases may require no special ventilation system.

(27) Ventilation systems should be designed and built so that they do not result in an unintended hazard. Hoods, ducts, air cleaners and fan are made from materials compatible with the gas used. Systems may require explosion-proof and corrosion-resistant equipment. Separate ventilation systems may be needed for some compressed gases to keep them away from systems exhausting incompatible substances.

Portable or Fixed Gas Detection

(28) Where gas storage areas may have the likelihood of flammable contaminants, a deprived or enriched oxygen atmosphere or a toxic atmosphere, as per a volumetric assessment regarding the type of gas and amount for the size of such area and reflected in a UQSafe risk assessment, a fixed gas detection system and audible or visual alarms shall be considered. Entry to such areas should be restricted.

(29) Portable gas detection will alert workers early and increase their occupational safety when an alarm has been raised regarding gas leaks.

Inspection and Maintenance of Equipment

(30) Leaks may develop in any part of a gas system, but particularly at joints. It is important that all equipment is regularly checked, and corrective action taken before use. As a matter of routine, always check for leaks when cylinders are stored and when they are assembled with equipment for use. When assembled, special attention should be paid to all joints and blowpipe valves.

(31) Use a supplier approved LDF (Leak Detection Fluid) or an ammonia free, soapy water solution applied with a brush. Warning – beware of the dangers of using LDFs which are incompatible with oxygen as LDF residues may cause spontaneous ignition. Only supplier approved LDFs should be used.

(32) Wipe the area dry with a clean lint-free cloth after you have completed the check. If there is any bubbling or foaming of the leak detection fluid during testing this indicates leakage. The equipment should be immediately depressurised, and the leak corrected.

- a. Regularly check for leaks and faults, only with approved leak detection fluid.
- b. Keep ammonia-based leak detection solutions, oil and grease away from cylinders and valves.
- c. Never use a flame when testing for leaks.
- d. Never tighten equipment while the equipment is under pressure.

(33) Entry into and exit from areas where gases are kept or handled should be kept clear at all times.

Written Procedures for Safe Operation and Handling

(34) Areas with gases storage should develop their own safe operating procedure for safe operating and handling that should include:

- a. system schematics, if required;
- b. operational steps;
- c. care for systems elements regulators, valves, gauges, nozzles, cylinders;
- d. system checks leaks, cleaning, deteriorations, labelling and their frequency;
- e. emergency and first aid response.

Emergency Response Plans and Systems

(35) Emergency plans must be developed wherever hazardous chemicals (including gases) are used, stored and handled. Possible hazards, incidents and emergency situations should be considered, including:

- a. likely types of emergencies (e.g., fires, gas leaks for each type of gas, explosion);
- b. the adequacy of firefighting systems;
- c. the adequacy of first aid (including safety showers and eyewash facilities);
- d. access to and from the site;
- e. a safe evacuation area;
- f. the need to notify neighbours;
- g. providing and testing alarms;
- h. carrying out regular emergency drills.

(36) Refer to the general guidance on <u>Emergency planning for hazardous chemicals</u> on the <u>Workplace Health and</u> <u>Safety</u> website.

(37) If gas products classified as hazardous chemicals are used, stored or handled in excess of the prescribed manifest

quantities in column 4 of schedule 12 of <u>the Regulation</u>, an emergency services manifest is required at the workplace. The manifest must contain an up-to-date inventory of hazardous chemicals used, stored and handled at the workplace, including the quantity and location of each gas storage area. Schedule 12 of <u>the Regulation</u> prescribes the information to be included in the manifest and site plan.

Personal Protective Equipment (PPE)

(38) Appropriate PPE must be available and provided in areas where cylinders are stored and handled, as follows:

- a. Eye protection (AS/NZS 1337), for impact.
- b. Safety footwear (AS/NZS 2210.2), for impact.
- c. Protective gloves (AS/NZS 2161), for manual handling and chemical handling.
- d. Hearing protection (AS/NZS 1270), if required by the risk assessment on the storage area.

(39) The provision of self-contained breathing apparatus, conforming with AS/NZS 1716, selected and maintained in accordance with AS/NZS 1715, will be considered on premises where toxic gases are kept or handled or where the oxygen deficient atmospheres could occur.

Section 5 - Storage

(40) All compressed gases are classified as dangerous goods and must be stored a suitable area to ensure health and safety. The requirements of the storage area will depend on the types and quantities of gas being stored. Gas cylinders should be stored outdoors, preferably in a secure cage that is protected from sunlight.

(41) Some general principles apply:

- a. Do not store gas cylinders in areas or structures constructed of combustible materials.
- b. Locate gas stores on the ground floor away from other dangerous goods (e.g., Class 3, 4, 5, 6.1, 7, 8 or 9, etc.) and combustible liquids (e.g., diesel fuel) stores by at least 5m or more.
- c. Avoid storing below ground level especially if flammable, toxic or asphyxiant gases are present.
- d. Store heavier than air gases with caution to avoid storing where these gases can collect in low lying areas.
- e. Avoid storing gas cylinders in significant quantities near to or inside protected places where members of the public may assemble (e.g., places of worship, theatres, childcare facilities, clinics, property boundaries).

(42) Where gas cylinders are stored indoors store in well ventilated areas to prevent build-up of escaped gases.

(43) Where gases are stored inside a building, a mechanical ventilation system may be required if the natural ventilation is inadequate. Expert advice should be obtained if unsure. Design the mechanical ventilation system to capture escaped gases, not ignite flammable gases. Ensure workers are not placed at risk of asphyxiation or exposed to gases above the relevant National Workplace Exposure Standard (WES).

(44) For workplaces where flammable gases are used, the risks of fire or explosion from ignition of the gas must be managed. If the possibility of a hazardous area is identified, then specific controls are required as described on the Queensland Worksafe information page for fire and explosion risks and hazardous areas will be identified according to AS 2430.1.

(45) In most laboratories or settings within UQ, minor storage quantity rules will apply. Storage of gases in cylinders in quantities not exceeding those in the table below (Figure 7) shall be classified as minor storage.

(46) Where gases of mixed classes are kept in minor storage, the aggregate quantity of all gases will not exceed 2000L and the quantity of each subclass shall not exceed that in the above table.

(47) For further information relating to electrical installations near flammable gas supplies, contact UQ Property and Facilities Division.

(48) Class 2.1 "Flammable gas" must be segregated during storage from all oxidising gases.

Safe Handling Practices

(49) Store cylinders in the upright position. Some gases (e.g. LPG and acetylene) contain a gaseous and liquid phase. Some flammable gas cylinders contain a pressure relief valve that must be in contact with the vapour phase if the cylinder is to function properly during an emergency. Some cylinders are designed so that they can be stored on their side, e.g. medical oxygen in an oxy-viva set. Consult the SDS or contact the supplier for additional information.

(50) Store gas cylinders in well ventilated areas to prevent build-up of escaped gases.

(51) Store gases outside in a cage where possible.

(52) Ensure cylinders are prevented from falling or being knocked over by securing them using a racking system or using a nonabrasive, coated chain that will not scratch the cylinder markings and paint work.

(53) Prevent damage to cylinders caused by impact from other objects (e.g. crashing into other cylinders). Some cylinders (e.g. acetylene) may react violently after being excessively shaken, heated, or knocked.

(54) Do not use cylinders as rollers to move other objects.

(55) When moving cylinders, avoid rolling them. Ensure that an appropriate mechanical handling device (e.g., cylinder trolley with a restraining strap) is used.

(56) Wear eye protection, safety shoes and gloves in gas cylinder storage and handling areas.

Heat and Ignition Sources

(57) Store cylinders in cool areas away from sources of radiant heat (e.g., boilers, hot surfaces, and internal combustion engines). Where possible, store cylinders in the shade to avoid exposing cylinders to direct sunlight.

(58) Do not store flammable gas cylinders near sources of ignition such as naked lights.

(59) Where flammable gas is used, erect appropriate signs stating, 'No naked lights' to prevent ignition sources in these areas.

(60) Wherever flammable gases are used, stored and handled, fire and explosion risks must be safely managed.

(61) Do not store gas cylinders in areas or structures constructed of combustible materials.

(62) Design the mechanical ventilation system to capture escaped gases, not ignite flammable gases. Ensure workers are not placed at risk of asphyxiation or exposed to gases above the relevant National Exposure Standard (NES).

Segregate Incompatible Gases and Hazardous Chemicals

(63) Store gas cylinders separately from other hazardous chemicals by at least 5m or by using appropriate fire-rated

barriers as:

- a. corrosive liquids can damage gas cylinders on contact;
- b. flammable liquids can spread a fire across a workplace floor and allow flames to come into contact with gas cylinders;
- c. other hazardous chemicals may also be adversely affected by gas cylinders in an emergency.

(64) Segregation of incompatible goods also allows fire fighters to safely use appropriate firefighting media for each type of goods present.

(65) Gas cylinders must also be segregated from other incompatible gases by at least 3m or more. The following is recommended:

- a. Store class 2.3 Toxic gas and corrosive gases (those with a subsidiary risk of class 8 Corrosive) away from all other gas cylinders.
- b. Segregate class 2.1 Flammable gas during storage from all oxidising gases.

Refer to Figure 8.

Figure 8: Segretation of gases

Class	2.1	2.2	2.2 (5.1)	2.3
2.1	С	С	R	1
2.2	С	С	С	I
2.2 (5.1)	R	С	С	I
2.3	1	1	1	С

C = Compatible

I = Incompatible and should be segregated by at least 3m

R = Reactive and should be segregated by at least 5m

(66) Mutually compatible gases (e.g. Class 2.2, without subsidiary risk) may be used between incompatible gases.

Medical Oxygen Cylinders

(67) Medical cylinders are only to be supplied with pin index valve outlets.

(68) Arrange for a replacement medical oxygen regulator to be able to connect to the new valve outlet if required. It is recommended the regulator supplier be contacted or medical gas supplier for assistance with requirements.

(69) Medical oxygen with manifold systems will need to have their manifold connections and/or flexible connections changed. Ensure a new pin-index cylinders have been tested for leaks.

General Housekeeping

(70) Do not store objects on top of gas cylinder.

(71) Store full and empty cylinders separately, in clearly marked areas.

(72) Rotate stock, ensuring a first-in-first-out process.

(73) Ensure gas cylinders are stored at least 3m away from combustible materials and debris (e.g. timber, cardboard, packaging materials).

(74) Do not locate gas cylinders where they may block stairs, exits, ladders or walkways.

- (75) Keep an up-to-date and accurate inventory.
- (76) Keep inventory quantities as low as possible.

Placarding

(77) Where gases are stored in excess of the placard quantities in specified in Schedule 11 'Placard and manifest quantities', Column 4 (Placard Quantity) of the <u>Work Health and Safety Regulation 2011</u>, placarding is required to be erected in the following locations:

- a. the main point of entry into a building;
- b. at either the main point of entry to a room or enclosure or other area;
- c. adjacent to the where the gas cylinders are being stored.

(78) Refer to Workplace Health and Safety Queensland Guide: <u>Placarding for Storage of Hazardous Chemicals</u> for further information.

Transport

(79) When moving cylinders, DO NOT roll or drag them. Ensure that an appropriate mechanical handling device is used. Secure cylinders upright to a proper hand truck or cylinder trolley with a restraining strap designed for the purpose. Cylinder size E and greater shall be handled using mechanical assistance. Contact the gas supplier if more sophisticated handling of cylinders is required.

Transport within Buildings

(80) Transporting cylinders between floors of a building will be done in the lift alone. No person is to travel in the lift with the gas cylinder. The cylinder trolley will be secured to the lift handrail to prevent it from falling over. Ideally a sign should be used across the entrance of the lift to prevent others entering the lift while the cylinder is in transit. Secure the cylinder immediately once arriving at the usage location.

Transport with Vehicles

(81) Gas cylinders used in the field may require the use of a vehicle to get them to the field site. Where possible, have the gas supplier deliver the cylinders directly to the field site. If a vehicle is required to transport cylinders, then it will be as follows:

- a. gas cylinders will only be transported on an open back utility OR in a utility back canopy that is separate from the main body of the vehicle.
- b. Cylinders should be transported standing up and firmly secured. Flammable and liquid withdrawal cylinders should always be transported in upright position.
- c. If cylinders are transported lying down then suitable support devices are required to prevent the cylinders from rolling. Also, settling time will be required for the cylinder before use place the cylinder in the upright position and wait 60 minutes before using. If acetylene has been laid on its side, then it is recommended that the cylinder is not used for 12-24 hours.
- d. Remove the gas cylinder(s) from the vehicle immediately on arrival to destination and secure them appropriately.

e. Do NOT carry gas cylinders of any kind in the passenger compartment of a vehicle.

Section 6 - 'Do's/'Don't's when Working with Gas Cylinders

DO	DON'T	
Ensure a regulator is fitted before use	Repaint a cylinder	
Ensure cylinder is firmly secured	Change the markings on a cylinder	
Ensure cylinders are stored and used away from ignition sources	Tamper with the gas cylinder test tag	
Store full and empty cylinders separately	Tamper with or remove the barcode from a gas cylinder	
Ensure valve guards or caps are fitted when cylinders are not in use	Roll cylinders along the ground	
Use mechanical assistance when handling cylinders	Attempt to fight a fire involving a gas cylinder	
Ensure adequate ventilation is available for the gas in question	Transport cylinders in the passenger compartment of a vehicle	
Ensure exposure limits are not exceeded	Use a cylinder that shows evidence of damage or corrosion	
Read the SDS	Fill cylinders with any material at all	
Follow appropriate SOP		
Have gas detection devices installed if required		

Section 7 - Roles, Responsibilities and Accountabilities

Head of Organisational Unit

(82) Provide the adequate time and resources to ensure that risk assessments are undertaken to determine the hazards and mitigating measures for gas cylinders in their area of control.

(83) Ensure that workplace inspections are carried out and that gas cylinders are reviewed as part of these inspections.

(84) Allow for the provision of adequate training to be undertaken by all that will use gas cylinders.

Supervisors

(85) Ensure for their work area, risk assessments are undertaken and the controls identified in the risk assessments, are implemented.

(86) Provide UQ workers with information, training and effective supervision about the hazards from gas cylinders, safe storage, appropriate placarding, handling information and what to do in an emergency.

UQ Workers

(87) Follow the guidance in this document to ensure that they do not put themselves or others at risk and follow all reasonable instructions as given by their Supervisors.

(88) Contribute to the development of risk assessments and in identifying any action plans to mitigate risks.

(89) If unsure about any aspect of the work activity involving gas cylinders, stop and seek appropriate assistance.

Section 8 - Monitoring, Review and Assurance

(90) The Health, Safety and Wellness Division will review this Guideline periodically. The workplace inspections undertaken in the organisational unit will inform any changes that need to be made to this Guideline to increase understanding for workers.

Section 9 - Appendix

Terms	Definitions
Asphyxiation	Breathing difficulties (suffocation), loss of consciousness and eventual death caused by an inadequate supply of oxygen to the body.
Flammable Gas	A gas that can be ignited in air.
Inert or Noble Gas	Any of the six gases helium, neon, argon, krypton, xenon, and radon. These gases are un-reactive except under certain special conditions.
Oxidizing Gas	A that initiates or promotes combustion of materials through release of oxygen. These gases can also spontaneously combust/explode.
UQ Workers	 For the purposes of this Guideline includes: 1. UQ staff, including continuing, fixed-term and casual staff; 2. contractors, subcontractors and consultants; 3. students, including post graduate researchers, higher degree by research students and undergraduate students; 4. visiting academics and researchers; 5. visiting research students; and 6. volunteers engaged by UQ that may be required to use flammable and/or combustible liquids.
Hazardous Area	An area (three-dimensional space) in which a flammable atmosphere is or may be expected to be present, and require special precautions for the construction, installation and use of equipment.

Status and Details

Status	Current	
Effective Date	4th November 2022	
Review Date	4th November 2027	
Approval Authority	Director, Health Safety and Wellness	
Approval Date	4th November 2022	
Expiry Date	Not Applicable	
Policy Owner	Jim Carmichael Director, Health Safety and Wellness	
Enquiries Contact	Health, Safety and Wellness Division	