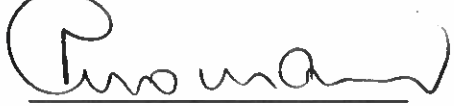



Complete Program Title: Compressed and Liquefied Gases Safety Program	Risk Management Manual (RMM) Number: 504
Approved by:  Vice-President, Administration  President and Vice-Chancellor	Date of Most Recent Approval: January 2019
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Responsible Executive: Vice-President, Administration	Enquiries: Environmental and Occupational Health Support Services (EOHSS) ehss@mcmaster.ca
DISCLAIMER: <i>If there is a discrepancy between this electronic program and the written copy held by the program owner, the written copy prevails.</i>	

1 PURPOSE

- 1.1 To define best practices for the safe use and storage of compressed and liquefied (cryogenic) gases.
- 1.2 To ensure compliance with the Occupational Health and Safety Act, Ontario Fire Code, Transportation of Dangerous Goods Act and the Criminal Code of Canada.

2 SCOPE

- 2.1 All individuals (staff, contractors and students) who are required to work with compressed and liquefied (cryogenic) gases (See Appendix b - List of Commonly Used Compressed Gases and Cryogenic Liquids).

3 Related Documents

- 3.1 Occupational Health and Safety Act (OHSA), R.R.O. 1990, Industrial Establishment Requirements
- 3.2 O. Reg. 860 R.R.O. 1990 –WHMIS.
- 3.3 Ontario Fire Code, O Reg. 388/97, Section 5.6.
- 3.4 Transportation of Dangerous Goods Act, R.S.C. 1992

- 3.5 McMaster University RMM# 100 Workplace & Environmental Health and Safety Policy.
- 3.6 McMaster University RMM# 300 Safety Orientation and Training Program.
- 3.7 McMaster University RMM# 312 Foot Protection Program.
- 3.8 McMaster University RMM# 310 Eye Protection Program.
- 3.9 McMaster University RMM# 311 Respiratory Protection Program.
- 3.10 McMaster University RMM# 505 Transportation of Dangerous Goods Program.

4 DEFINITIONS

- 4.1 **Compressed Gas** - Any product, material, or substance contained under pressure including dissolved gas or a gas liquified by compression or refrigeration that has a critical temperature of less than 50 °C, an absolute vapour pressure of greater than 275.8 kPa at 21 °C or 717 kPa at 54 °C, or both, or any liquid having an absolute vapour pressure exceeding 275.8 kPa at 37.8 °C.
- 4.2 **Cryogenic Fluids** – Liquified gases at very low temperatures (usually below – 73. 3 °C). The most common laboratory cryogenic fluid is liquid nitrogen (See Appendix B - List of Commonly Used Compressed Gases and Cryogenic Liquids).
- 4.3 **Ensure** – Take every reasonable precaution to achieve the stated objective.
- 4.4 **Shall** – A legal term meaning must.
- 4.5 **Supervisor** – Person who has charge of a workplace or authority over a worker.
- 4.6 **Transfilling** – The transfer of contents between cylinders.
- 4.7 **Worker** – means any of the following, but does not include an inmate of a correctional institution or like institution or facility who participates inside the institution or facility in a work project or rehabilitation program:
 - 1. A person who performs work or supplies services for monetary compensation.
 - 2. A secondary school student who performs work or supplies services for no monetary compensation under a work experience program authorized by the school board that operates the school in which the student is enrolled.
 - 3. A person who performs work or supplies services for no monetary compensation under a program approved by a college of applied arts and technology, university or other post-secondary institution.
 - 4. A person who receives training from an employer, but who, under the Employment Standards Act, 2000 (ESA), is not an employee for the purposes of that Act because the conditions set out in subsection 1 (2) of that Act have been met.
 - 5. Such other persons as may be prescribed who perform work or supply services to an employer for no monetary compensation; (“travailleur”).

5 Acronyms:

JHSC – Joint Health and Safety Committee

CJHSC – Central Joint Health and Safety Committee

EOHSS – Environmental and Occupational Health Support Services

OHSA – Occupational Health and Safety Act

FHS – Faculty of Health Sciences

6 RESPONSIBILITIES

6.1 Role of Senior Management: (Deans/Directors/Chairs)

Senior Managers shall:

- provide the resources necessary to implement and maintain the Compressed and Liquefied Gases Safety Program within their area of responsibility; and ensure all compressed and liquefied gas storage and use within their area of responsibility complies with this program.

6.2 Role of Supervisor

The responsible supervisor shall:

- ensure that only trained and authorized individuals are assigned to work that involves the use, handling or storage of compressed and liquefied gases
- ensure that only approved and clearly identified cylinders and containers are used for the storage of compressed and liquefied gases;
- ensure that compressed and liquefied gas cylinders and containers are safely secured and stored in well ventilated areas;
- provide current Safety Data Sheets (SDS) for all compressed and liquefied gases used in the workplace;
- provide and post an SOP and appropriate signage at all liquefied gas filling stations (See Example Appendix A);
- provide all required personal protective equipment i.e. face, hand, foot and body protection;
- ensure the authorized individuals are trained in the safe use, care and storage of personal protective equipment;
- ensure that all individuals supervised by them who are required to use, handle or store compressed and liquefied gases have received both WHMIS training and gas cylinder training;
- ensure that all individuals supervised by them who use, handle or store compressed and liquefied gases are trained in the safe handling, use and storage procedures as outlined in Section 6 of this Program to become authorized people;

- maintain training records of authorized people; and
- maintain an inventory of compressed and liquefied gases in the work area.

6.3 Role of Authorized Individuals

Individuals authorized to use, handle or store compressed and liquefied gases shall:

- be trained in the safe handling, use and storage procedures as outlined in Section 6 of this Program;
- follow all procedures for the safe handling, use and storage of compressed and liquefied gases (See Section 6 of this Program);
- review the SDS prior to use for all compressed and liquefied gases used in the workplace;
- use protective equipment and clothing when handling compressed and liquefied gases e.g. face shields, gloves, respirators etc.; and
- report all incidents involving personal injury and accidental spills or releases of compressed and liquefied gases to their immediate supervisor and fill out an incident / injury form.

6.4 Role of Environmental and Occupational Health Support Services

The EOHSS Office shall:

- coordinate with the CJHSC in developing programs and policies for the safe management and audit of the use, handling and storage of compressed and liquefied gases; coordinate the development of training initiatives; and
- develop and deliver training programs for the safe use, handling and storage of compressed and liquefied gases in consultation with user groups and the JHSCs.

6.5 Role of Joint Health and Safety Committee

The JHSC shall:

- audit processes and inspect facilities where compressed and liquefied gases are used in the workplace; and
- review all incident reports related to the use, handling and storage of compressed and liquefied gases.

6.6 Role of Central Joint Health Safety Committee

The CJHSC shall:

- review and make comment on the Compressed and Liquefied Gases Safety Program on a regular basis.

7 PROCEDURES

7.1 Training

All individuals required to handle, use or store compressed and liquefied gases shall receive training that includes but is not limited to the following:

7.1.1 WHMIS training.

7.1.2 Hazards Associated with Compressed and Liquefied Gases that include but is not limited to the following information, as available in gas cylinder training and specific training provided by supervisor:

- (i) A falling cylinder may cause personal injury and or damage to property;
- (ii) If a cylinder valve is sheared off, the cylinder may become a dangerous projectile;
- (iii) Damaged or faulty valves or regulators may cause release of pressurized gas and can result in oxygen depletion/displacement in a confined enclosure;
- (iv) Elevated temperatures, as in the case of fire, may cause the sudden release of hazardous gas;
- (v) Cryogenics are extremely cold liquids that present frostbite hazards;
- (vi) Liquid oxygen can cause ordinary materials to become extremely flammable or in some instances explosive; and
- (vii) Toxic and corrosive gases can cause irreversible respiratory disease which can be fatal.

7.2 Work Procedures

Guidelines for the Storage and Use of Compressed Gas and Cryogenic Gases

7.2.1 Storage of Compressed Gas Cylinders:

- (i) Cylinders of compressed gas which are not in service, shall be equipped with valve caps or will have the engineered hard plastic protective yokes, and shall be stored in an area where the ambient temperature does not exceed 52 °C;
- (ii) Cylinders shall be stored in secure areas and not in areas of egress such as aisles, hallways, doorways, stairwells or exits. All cylinders shall be securely chained and/or strapped to wall high enough so as to avoid tipping and clearly labelled with the name of the owner and the date acquired;
- (iii) Flammable compressed gases shall not be stored indoors unless the storage area is specifically designed for flammable compressed gases;
- (iv) Cylinders of gases that may react with one another shall not be stored adjacent to one another (e.g. oxygen and hydrogen);
- (v) Indoor storage areas for inert gases shall be dry and well ventilated and kept free of combustible materials. Storage rooms containing such gases shall have door signs indicating the nature of the compressed gases; and
- (vi) Cylinders shall have proper WHMIS labelling.

7.2.2 Handling and Use of Compressed Gas Cylinders

- (i) Use a 3 or 4 wheeled gas cylinder cart to transport cylinders. Never move a cylinder without the safety cap on and never roll a cylinder, even for short distances;
- (ii) Because of the nature of their construction, acetylene cylinders shall be kept in an upright position;
- (iii) Copper tubing shall not be used with acetylene gas as it forms explosive compounds on contact with acetylene;
- (iv) Propane cylinders shall be stored and or installed such that the pressure relief valve is not in the liquid phase inside the cylinder;
- (v) All cylinders shall be protected from mechanical damage and shall be secured by a restraining strap or chain while in service. Bungee cords are not acceptable. Check that cylinder clamp straps and buckles are in good condition before using. Remove and report faulty clamps to Supervisor.
 - (i) Where a flammable gas or compressed gas is heavier than air (e.g. propane), only one cylinder per room per building shall be in service. Such gases shall not be used in basements unless oxygen sensors are used and auxiliary ventilation is supplied. Propane barbeques shall not be used inside buildings or on balconies;
 - (ii) Toxic and corrosive gases shall be used only in a continuously ventilated enclosure;
 - (iii) Cryogenics shall be used only in well-ventilated areas;
 - (iv) Compressed gas cylinders shall only be used with a pressure reduction regulator attached to the valve;
 - (v) The regulator shall be appropriate for the gas (check CGA regulations); regulator adapters shall not be permitted. Choose a regulator with the correct pressure output range. Ask the lab Supervisor or experienced lab personnel if unsure. Check that the regulator is in good condition (all valves/knobs move freely; no obvious obstructions and threads on the cylinder and regulator are in good condition). Never modify a regulator or use one that has been altered;
- (vi) The regulator shall not be used as a shut-off valve;
- (vii) Oil and grease shall not be allowed to come in contact with oxygen or other oxidizing gas cylinders or their attachments;
- (viii) Regulators and associated piping shall be checked for leaks periodically and every time a cylinder is replaced;
- (ix) Leaking regulators shall be returned to the manufacturer for repair;
- (x) Teflon tape shall not be used to repair a leaking connection between the regulator and gas cylinder;
- (xi) Cylinders shall be situated so that the cylinder shut-off valve is accessible at all times; and;
- (xii) Transfilling compressed gas cylinders is prohibited.

6.2.3 Handling and Use of Cryogenic Gases

- (i) Cryogens shall be stored in a secure area only in vacuum-jacketed dewar flasks designed for that purpose. All such dewars shall be designed to accommodate relief of pressure, either by the use of loose-fitting stoppers or by specifically designed fittings; and
- (ii) Personal protective equipment including a face shield, loose-fitting cryogenic gloves and trousers that fit over the tops of closed-top shoes or boots shall be worn when pouring cryogenic fluids. Because of the possibility of rupture of the sample container due to pressure build-up, a face shield shall be worn when removing samples (e.g. microfuge tubes) from storage dewars.

8 Records

- 8.1 WHMIS as well as all safety training records for persons authorized to handle, use or store compressed and liquefied gases shall be maintained by the supervisor; and
- 8.2 Inventory of compressed and liquefied gases used or stored in the workplace, shall be maintained by the supervisor.

Appendix A EXAMPLE

Facility Services
McMASTER UNIVERSITY
LIQUID NITROGEN – FILLING STATION PROCEDURE
(SITUATED IMMEDIATELY EAST OF ABB RECEIVING DOCK)

Only authorized and trained personnel may perform the filling of liquid nitrogen. Training constitutes formal training by the supplier of liquid nitrogen or a competent expert and training in the following procedures.

Worker shall not leave the dewar units unattended while refilling or dispensing liquid nitrogen on the platform.

PROCEDURE

1. Drop lift gate of vehicle, gradually back vehicle up to the fill station platform.
2. Unlock padlock on gates, and slide each side of gates back on the track. Unlock and open the side door to permit access and egress.
3. Enter the platform station area and remove required tools and personal protective equipment from storage container.

Personal Protective Equipment:

Goal is to protect the skin/eyes/hands/feet from liquid nitrogen burns -196 degrees Celcius.

Eyes/Hearing/Hand/Skin (legs/arms/face) required protection and the following shall be worn or used:

CSA Footwear

Hearing Muffs/Plugs

Loose Fitting Gloves (to permit easy removal in case of an incident)

Face shield or hand held Plexiglas shield

Long Pants (do not tuck pant legs into boot) & Sleeves or Coverall (or Lab Coat)

Tools:

Cell telephone, heat gun, wrench, hoses. Cloths, ¾" round plywood cut to fit on top of unit, inspection form and record book.

4. Don the appropriate Personal Protective Equipment as advised above.
5. Carefully release and gradually lay the dock plate down onto the box of the vehicle.

6. Check the condition of the dewar unit and report on the inspection form any unusual or noticeable structure damage to the outside container including valves. Ensure this completed form is provided to the supervisor by the shift end.
7. Remove empty cylinders/canisters from the vehicle and place on the platform station.

Refilling the Dewar

Canisters (dewar units without manifold)

- Place canister(s) on the east side of the refill feeder;
- Remove cap or top of canister (lift up);
- Place one end of refueling rod into the empty canister and attach the opposite end to the dispensing valve of the refill feeder and hand tighten by twisting nut. (DO NOT use the wrench to tighten the nut, may freeze.);
- Worker shall use the hand-held portable Plexiglas shield as a barrier to protect from splash or spit of liquid nitrogen;
- Turn the refill feeder (shut-off) valve ON to allow the canister to be filled with liquid nitrogen (often these styles of canisters do not have a gauge to indicate when full. Check filling visually by watching for the liquid nitrogen to spit from the top of the opening. Gradually, reduce the pressure by turning the refill feeder (shut-off) valve towards OFF position. As canister is nearing full, the liquid nitrogen will spit and flow over the opening, turn OFF the refill feeder (shut-off) valve);
- Unscrew the rod from the dispensing valve feeder by hand and remove the rod from the filled canister; and
- Replace the lid back on the canister.

Cylinders (dewar units without manifold)

- Place on the west side of the refill feeder;
- Open liquid and vent valves on top of cylinder to depressurize unit simultaneously by twisting with the hand;
- Place hose on refill station valve and tighten with wrench;
- Place the opposite end of hose onto the opening liquid cylinder valve and tighten with wrench;
- Turn the refill feeder (shut-off) valve ON to allow the cylinder to be filled with liquid nitrogen. (Most cylinders have a gauge to indicate when it is full.) Check filling visually by watching for the liquid nitrogen to spit from the top of the opening. Gradually reduce pressure by turning the refill feeder (shut-off) valve towards OFF position. As cylinder is nearing full, the liquid nitrogen will spit and flow over the opening, turn OFF the refill feeder (shut-off) valve.) (Cylinder with a gauge would indicate full.);
- Using a wrench, loosen and remove the hose from the cylinder. Close liquid and vent valves on the cylinder simultaneously; and
- Using a wrench, loosen and remove hose from the refill feeder valve.

8. Record the canister/cylinder number in the log book.

9. MATERIAL HANDLING:

- Dewar units exceeding 25 lbs shall be listed by two persons and the unit kept in an upright position.
- Move the units carefully to prevent damage to handles/valves.
- Dewar unit(s) shall be braced securely in the vehicle.

10. Pull dock plate up.
11. Remove PPE. Return tools, PPE and record book to the storage container.
12. Exit the platform station area.
13. Slide gates back into closing position on the track, and padlock. Close and padlock the side gate door.

Emergency:

- For burns, immediately exit the platform and use the shower rinse station on the ABB Receiving dock (refer to First Aid).
- Should there be equipment failure with the liquid nitrogen holding tank, immediately exit the platform and contact Security (dial 88) in the (adjacent building) E. T. Clarke Centre, 2nd floor.
- Report any event, incident/injury immediately to the supervisor.

First Aid:

- If cryogenic liquid is spilled on body parts, remove clothes IMMEDIATELY (in all cases). Frozen clothing sticking to the skin should be thawed and carefully removed.
- Look for signs of 'frost bites', especially on hands and feet. Frozen tissues appear yellow and waxy.
- 'Frost bites' are painless until they defrost and then become particularly painful.
- Rinse affected body parts with plenty of water not exceeding 40 o C for at least 30 minutes.
- Use gentle water flow in sufficient quantity.
- Do not rub affected regions, as it may further damage tissues.
- Seek prompt medical assistance in all cases (dial 88).
- In some cases of massive exposure, the general body temperature decreases. If immediate medical assistance is not available, place the patient in a warm bath not exceeding 40oC.
- Although frozen body parts are painless, thawing of frozen tissues is very painful.
- Do not smoke or drink alcohol.

Updated: Amended Dec/08
Data/Education/SOP Liquid Nitrogen

Appendix B

Dewar Defect Report

Date: _____ Time...A.M...P.M.

Dewar Owner: _____

Building and Room #: _____

Extension: _____

Person Making Report: _____

Type of Damage or Concern, please check mark or add in comment area

- Damaged Valve / Vacuum valve
 - Valve Handle
 - Threads on Liquid Port
 - Other:
 - Damaged Casters
 - Damaged Handle
 - Damaged body (explain)
 - Dent:
 - Scrapes:
 - Other:
 - Dewar Frosting at base
 - Attachments left on Dewar (e.g., hose, extra fittings, etc.)
 - Cap missing/Damaged
- Dewar filled Dewar not filled

Appendix C

Common Compressed Gases

Transport Classification	Examples
Flammable	Hydrogen, acetylene, propane, methane, butane, ethane, ethylene, isobutane, silane, vinyl chloride
Inert	Helium, neon, nitrogen, carbon dioxide, air, sulphur hexafluoride.
Toxic	Carbon monoxide, phosgene, nitric oxide, arsine, chlorine, trifluoride, cyanogen, methyl bromide, nitrogen trioxide.
Corrosive	Hydrogen chloride, boron trifluoride, ammonia, chlorine
Oxidizers	Oxygen, nitrous oxide

Common Cryogenic Liquids

Gas	Normal Boiling Point Degrees °C	Volume Expansion to gas
Helium	-268.9	757 to 1
Hydrogen	-252.7	851 to 1
Nitrogen	-195.8	696 to 1
Argon	-183.7	847 to 1
Oxygen	-183.0	860 to 1
Carbon Dioxide	-78.5	553 to 1