CONTROL PROGRAM for LIQUID CRYOGENIC TRANSFER FACILITIES / OTHER LOW OXYGEN HAZARDOUS ROOMS

1.0 INTRODUCTION AND SCOPE

The University of Toronto is committed to protecting the health and safety of its employees and students, in accordance with its Health and Safety Policy and its responsibilities under the *Occupational Health and Safety Act of Ontario*.

The Control Program for Liquid Cryogenic Transfer Facilities is intended to control the hazards associated with the storage, handling and transfer of liquid cryogens within centralized departmental transfer locations. Additionally, the control program applies to other common locations where liquified gases are found – and potentially creating an oxygen deficient atmosphere:

- Nuclear Magnetic Resonance (NMR) rooms / laboratories

The basic elements of the Program are as follows:

1. the identification of all liquid cryogenic transfer facilities and NMR labs at the University;
2. the provision of appropriate design criteria for transfer facilities;
3. the provision of appropriate safety design requirements for pressurized systems used for liquid cryogenic materials;
4. the installation of oxygen monitoring devices to continually monitor oxygen levels.
5. the provision of appropriate standard operating procedures for the activities conducted within transfer facilities, including storage, dispensing, and handling of cryogenic materials;
6. the requirement for personal protective equipment where there is the potential for exposure to or contact with liquid cryogenic materials;
7. the training and education of all workers who supervise or conduct work within liquid cryogenic transfer facilities; and
8. the provision for reviewing the implementation and effectiveness of the program.

Scope

This Program applies to all departmental cryogenic transfer and storage facilities for liquid nitrogen, liquid helium or liquid argon, and those who supervise or conduct work within such facilities.

2.0 DEFINITIONS

Cryogenic Liquid

A cryogenic liquid is one which has a normal boiling point below -150 C, as defined by the National Bureau of Standards, Handbook 44. Commonly used cryogenic liquids include nitrogen, argon and helium.

Cryogenic System, Closed

A system containing cryogenic liquids or their boil off gases which has no direct connection to the atmosphere. Such a system may be made up of vessels, lines, connections, valves, fittings or any other hardware.

Cryogenic System, Pressurized

Any system, including pressure vessels, lines, connections, valves and any other hardware that contains cryogenic liquids or gases under pressure greater than atmospheric.

Facility Supervisor

A facility supervisor is one who has charge of a liquid cryogenic transfer facility, or authority over the activities related to the storage or transfer of cryogenic liquids within the facility.

Facility Worker

An individual who performs work within a liquid cryogenic transfer facility.

Liquid Cryogenic Transfer Facility

A liquid cryogenic transfer facility is any physical location designated as such by the pertinent Department which:

(a) is a central source of cryogenic liquid(s) to the department; and

(b) has bulk quantities of cryogenic liquids stored and/or dispensed within it.

3.0 HAZARDS OF LIQUID CRYOGENS

The general hazards associated with liquid cryogens are summarized as follows:

3.1 Oxygen Deficiency

The release of cryogenic liquids in the work area can result in the rapid displacement of air and the potential for asphyxiation (suffocation) by reducing the concentration of oxygen in air below levels necessary to support life.

Cryogenic liquids have very high volume expansion rates. For example, one litre of liquid nitrogen spilled in an enclosed area will expand to approximately 700 litres of nitrogen gas at standard temperature and pressure.

Exposure to oxygen-deficient atmospheres may produce dizziness, nausea, vomiting, loss of consciousness and death. Such symptoms may occur in seconds without warning. Death may result from errors in judgement, confusion or loss of consciousness which prevents self-rescue.

3.2 Pressure Build-Up Hazard

Overpressurization will develop in inadequately vented pressurized systems due to the expansion of cryogenic liquid vaporizing into large volumes of gas. Sudden release of this pressure can cause personal injury by issuing cold gas or liquid, or by expelling parts, as a result of leaks or bursts. In rare, extreme cases, explosions can result. The low temperatures of liquid cryogens also result in their potential to freeze water or other materials rapidly, and subsequent blockage and pressure build-up.

3.3 Cryogenic Burns and Frostbite

Exposure to liquid cryogens or the cold "boil off" gases can result in extensive tissue damage or severe skin burns. Contact with uninsulated pipes or metal containers which are used to contain or transfer cryogenic materials can cause the flesh to stick and be torn when attempts to withdraw it are made. Prolonged exposure to cold can also result in frostbite.

3.4 Cold Stress to Materials

Common materials such as carbon steel, plastics and rubber can become brittle and weak, or fracture under stress at cryogenic temperatures. These can cause spills or leakages as a result of system rupture or failure.

3.5 Condensation of Atmospheric Oxygen

Oxygen in surrounding air can condense when exposed to the temperatures of cryogens such as liquid nitrogen. Such oxygen enrichment may result in increased flammability and explosion hazards. When exposed to liquid oxygen, ordinarily inert substances like wood or grease can ignite or explode.

4.0 RESPONSIBILITIES

This section outlines the responsibilities within the University for the implementation of the Control Program for Liquid Cryogenic Transfer Facilities.

4.1 Department Heads

Department Heads have the following responsibilities within the Control Program:

1. To designate as a liquid cryogenic transfer facility, any physical location under their jurisdiction which meets the definition and pertinent criteria;

2. To designate an individual who has charge of the liquid cryogenic transfer facility or authority over the activities conducted within (facility supervisor);
3. To ensure that all components of the Control Program are implemented in the transfer facilities;
4. To ensure that pertinent supervisors and workers are fully informed of their duties and responsibilities under the Control Program;
5. To ensure that appropriate procedures, equipment and materials are provided in cryogenic transfer facilities for the protection of the health and safety of all workers;
6. To ensure that all workers are given sufficient, information, instruction and supervision to enable them to work safely in cryogenic transfer facilities.
7. The department is responsible for ensuring oxygen monitoring devices are installed, maintained, and calibrated as per guidance in this protocol.

4.2 Facility Supervisor

A facility supervisor is one who has charge of a liquid cryogenic transfer facility or authority over the activities conducted within. The facility supervisor must be familiar with the requirements of the Control Program for Liquid Cryogenic Transfer Facilities, the education and training requirements for cryogenic safety, and the potential hazards and associated controls of liquid cryogenic materials.

The facility supervisor has the following responsibilities within the Control Program:

1. To ensure that the Control Program is implemented in those transfer facilities under his/her control;
2. To maintain a record of all liquid cryogenic transfer facilities under his/her jurisdiction;
3. To notify the Office of Environmental Health and Safety of the locations of liquid cryogenic transfer facilities under his/her jurisdiction;
4. To develop written standard and emergency operating procedures for all activities associated with the storage and transfer of cryogenic liquids within the transfer facilities under his/her control;
5. To ensure that appropriate procedures, equipment and materials are provided in transfer facilities to protect the health and safety of all workers;
6. To ensure that all workers under his/her authority are provided with appropriate training and education to enable them to work safely within the transfer facility;
7. To restrict access to the transfer facility to workers who have received appropriate training and education in the hazards of liquid cryogens and the proper procedures for working safely within the facility;
8. To ensure that all individuals who utilize the transfer facility work in accordance with established procedures;
9. To report all accidents that take place within the transfer facility to the Office of Environmental Health and Safety.

10. To ensure that the emergency response program is implemented for the transfer facility, and that all workers have received appropriate information and instruction with respect to emergency response.

4.3 Facility Workers

All workers, including employees and students, who utilize a liquid cryogenic transfer facility have the following responsibilities:

1. To work in compliance with the Control Program and departmental safety policies and procedures;
2. To participate in cryogenic safety training provided by their supervisors and apply this training to their work;
3. To report promptly any accidents, unsafe conditions or unsafe procedures within a cryogenic transfer facility to the facility supervisor and their individual supervisor.

4.4 Office of Environmental Health and Safety

The Office of Environmental Health and Safety has the following responsibilities with respect to the Control Program:

1. To develop and maintain the Control Program for Liquid Cryogenic Transfer Facilities;
2. To maintain an inventory of all reported transfer facilities at the University;
3. To provide technical support to departments with transfer facilities in the implementation of the Program;

4.5 Joint Health and Safety Committee

The joint health and safety committee has a key role in the development and ongoing implementation of the Control Program:

1. The committee may inspect pertinent liquid cryogenic transfer facilities during routine workplace inspections for the purpose of hazard identification;
2. The committee must be consulted by the University with respect to the Control Program and any worker training program related to cryogenic safety.

5.0 DESIGNATION OF LIQUID CRYOGENIC TRANSFER FACILITIES

5.1 The pertinent Department Head is responsible for designating a physical location as a liquid cryogenic transfer/NMR facility if it meets the criteria indicated in Section 6.0. This may be conducted in consultation with the Office of Environmental Health and Safety.

5.2 The Facility Supervisor is responsible for maintaining a record of the transfer facilities under his/her jurisdiction by informing the Office of Environmental Health and Safety via email at ehs.office@utoronto.ca .

5.3 The Facility Supervisor shall inform the Office of Environmental Health and Safety of any changes to the location of or operations conducted within the transfer facility..

5.4 The Record of Designated Liquid Cryogenic Transfer Facilities shall include the following information:

- Department;
- Location of the Facility (building; room number)
- Facility Contact Person
- Description of Facility Operations - liquid cryogen related (types, volumes) and non liquid cryogen related

5.5 The Office of Environmental Health and Safety shall develop and maintain an inventory of all designated liquid cryogenic transfer facilities at the University of which they have been informed.

6.0 FACILITIES DESIGN

The design of transfer facilities must take into account the hazards of cryogenic materials being used, stored or handled in the area. If hazardous materials other than liquid cryogens are also being used within the same workspace, the facility design will need to incorporate appropriate safety guidelines in keeping with these hazards.

6.1 The dimensions of the cryogenic transfer facility shall be sufficient to allow equipment and personnel free and unobstructed movement.

6.2 Adequate dilution and/or local mechanical ventilation shall be provided within the transfer facility to control the build-up of cryogenic gases generated by the activities conducted within.

6.3 The mechanical ventilation system within a transfer facility shall be equipped with an appropriate mechanism to promptly alert workers of any malfunction to the system.

6.4 The transfer facility shall be equipped with an oxygen sensor and alarm system. A transfer facility may be exempted from this requirement only under exceptional circumstances and only after an assessment conducted in conjunction with the Office of Environmental Health and Safety has demonstrated that there are appropriate methods in place to warn of oxygen-deficient conditions.

6.5 Clearly visible warning signage shall be posted at each transfer facility, to include the following information:

- a warning of the type of hazard (e.g. asphyxiation; cryogenic material)
- appropriate precautions to be taken (e.g. proper safety procedures, personal protective wear);
- a statement requiring the continued presence of all users during any transfer operation;
- name of contact person or facility supervisor;
- appropriate emergency procedures.

7.0 OXYGEN MONITORING DEVICES

7.2 The installation of the oxygen monitoring device will rely on the manufacturer's specific requirements and recommendations. EHS will provide additional guidance, where applicable, on the installation, maintenance, and calibration of the oxygen monitoring devices.

Some of these requirements may include, but not be limited to, the following:

1) Installing the device close to an area where a leak would be most likely to be detected in time for occupants to safely leave the area. Cryogenic liquid suppliers can often be of great assistance in selecting a location.;
2) Placing the device at the proper height to avoid unnecessary false alarms.; 3) Ensuring the device's display is accessible;

As per the manufacture's recommendation, a low oxygen alarm shall be installed along with the monitoring device to alert persons in the surrounding area of a potential hazardous condition.

The Ontario Occupational Health & Safety Act specifies that an atmospheric hazard means, an oxygen content in the atmosphere that is less than 19.5% or more than 23% (*Ontario Regulation 632/05 Confined Spaces)* . The device alarm and warning levels should be set according to these oxygen concentration levels.

7.3 Calibrations are performed as prescribed by the manufacturer to verify the accuracy of the oxygen sensor, which is the main component of an oxygen monitoring device. Records must be kept of all calibrations, preferably in a designated notebook located near the alarm (readily available).

Interval Calibrations. These calibrations should be performed by the manufacturer or manufacturer's representative either every 6 months or per the recommendation of the manufacturer, whichever is more frequent. A more frequent calibration schedule may be necessary if readings are out of range.

8.0 PRESSURE VESSELS AND TRANSFER SYSTEMS

Pressurized systems involving the use of cryogenic materials may include pressurized vessels, hoses, piping, fittings and pressure relief devices. Only equipment and vessels designed for the intended product, service pressure and temperature shall be used in cryogenic transfer facilities.

8.1 Pressurized vessels shall be vacuum-insulated and designed in accordance with the current version of the Canadian Standards Association (CSA) Boiler, Pressure Vessel and Pressure Piping Code B51. All pressurized vessels and pressure relief devices must be stamped with a Canadian Registration Number.

8.2 Transfer hoses shall be constructed of a material that will not become brittle and weak or fracture under stress at cryogenic temperatures, e.g. flexible stainless steel.

8.3 Closed cryogenic systems must have independent pressure relief devices for each component or segment of piping and hose that is isolated by valves.

8.4 All piping and fittings shall be in accordance with the CSA Code B51.

8.5 All vessels and transfer components designated for cryogenic liquids must be routinely inspected for structural integrity.

9.0 PERSONAL PROTECTION

Due to the extremely cold temperatures of cryogenic liquids and "boil off" gases, or the components they are in contact with, contact shall be prevented or minimized at all times.

9.1 The facility supervisor shall ensure that appropriate personal protective equipment is available to workers who utilize the transfer facility. Such protective equipment shall as a minimum include goggles / face shields and loose fitting thermal gloves.

9.2 The facility supervisor shall ensure that all workers who utilize the transfer facility wear appropriate personal protective equipment as required.

9.3 The facility supervisor shall ensure that all protective wear provided is in good condition and is routinely checked for defects.

9.4 All workers must promptly report any missing or defective personal protective equipment to the facility supervisor.

10.0 STANDARD OPERATING PROCEDURES

10.1 The facility supervisor shall develop written standard operating procedures for each liquid cryogenic transfer facility under his/her authority.

10.2 The facility supervisor shall ensure that all users of the facility are familiar with the standard operating procedures and their respective responsibilities.

11.0 TRAINING AND EDUCATION

11.1 Facility supervisors must ensure that all workers under their charge who are to work in and around the cryogenic transfer facility are provided with appropriate training and education in cryogenic safety.

11.2 Facility supervisors shall maintain records of worker training and education.

11.3 Facility supervisors shall ensure that all other workers have undergone appropriate training in cryogenic safety prior to performing work within the cryogenic transfer facility.

11.4 A cryogenic safety training program shall include:

- properties and hazards of liquid cryogens;
- identification and evaluation of cryogenic hazards associated with operations and equipment;
- methods of controlling cryogenic hazards;
- oxygen monitoring devices
- standard operating procedures for the transfer facility;
- proper use and care of personal protective equipment and clothing;
- emergency procedures.

11.5 All workers must participate in appropriate training in cryogenic safety and apply such training to the activities they conduct within the facility.

12.0 PROGRAM REVIEW

12.1 On behalf of the University, the Office of Environmental Health and Safety is entitled to review the implementation of this program and its specific provisions on an as required basis..

13.0 REFERENCES

National Institutes of Health (NIH). Protocol for Use and Maintenance of Oxygen Monitoring Devices. (May 2010) http://www.ors.od.nih.gov/sr/dohs/Documents/ProtocolOxygenMonitoring.pdf