Working Safely with Liquid Nitrogen and Dry Ice Guideline

Section 1 - Purpose and Scope

(1) Cryogenic substances such as liquid nitrogen (LN) and dry ice are widely used throughout The University of Queensland (UQ). Cryogenic liquids and solids create significant risk to the health and safety of workers and students if not stored and handled correctly. This Guideline identifies the hazards and outlines the control measures.

(2) This Guideline provides information on methods to minimise the likelihood of injuries and illnesses occurring from the use and storage of liquid nitrogen and dry ice. This Guideline has been developed to meet selected criteria of:

a. AS 2243.2 Safety in Laboratories - Chemical aspects and storage; and
b. AS 1894 The Storage and handling of non-flammable cryogenic and refrigerated liquids.

(3) This Guideline applies to all UQ workers (including staff, higher degree by research students, contractors, volunteers) and others (undergraduate students, visitors, clinic clients), across all UQ operations and sites who handle dry ice and liquid nitrogen.

Section 2 - Process and Key Controls

(4) All UQ workers have a duty under the Work Health and Safety Act 2011 to ensure the risk of asphyxiation or cryogenic burns is eliminated or minimised as far as practicable.

(5) This document should be read in conjunction with Australian Standard AS 1894: The storage and handling of non-flammable cryogenic and refrigerated liquids, Australian Standard AS 2243.2: Safety in Laboratories - Chemical aspects and storage and UQ's policies and procedures related to Occupational Hygiene and Chemical Safety.

Section 3 - Key Requirements

Part A - Risk Management

Risk assessment and procedures

(6) All tasks undertaken at UQ using cryogenic substances should have a thorough safe operating procedure (SOP) and a risk assessment in UQSafe with reference to the appropriate Safety Data Sheet/s (SDSs), and be approved by the applicable Supervisor prior to use.

(7) UQ workplaces should consider higher risk management controls including specific plant and engineering requirements as outlined in AS 1894: The Storage and handling of non-flammable cryogenic and refrigerated liquids.

Control of risks

(8) Asphyxiation - all dewars and dry ice containers must be designed for purpose and must be located in well-

ventilated areas to allow for gas venting. Any transfer from the original storage should be into an appropriate transport container and UQ workers must not be in an enclosed space or small room (e.g. such as lifts, walk in freezer) where oxygen depletion may be an issue. Note: This does not include the transport of small quantities of LN (1 litre or less) in lifts; this process has been risk assessed and found to be acceptable due to the small quantities of LN involved.

(9) Work with dry ice should be in a fume hood or appropriately ventilated area, reaching over into a large dry ice esky should be avoided. Storage areas where oxygen displacement can occur must be risk assessed and should have an oxygen depletion alarm installed where required. Dewars of LN, samples packed in dry ice, or dry ice for re-use should not be stored in walk-in cold rooms. Fainting caused by a pocket of low oxygen air may still cause significant injury, therefore samples containing dry ice should not be stored in chest or vertical fridge or freezers.

(10) Cryogenic burns – Where a risk assessment states and where appropriate, personal protective equipment (PPE) such as thermal gauntlet gloves, face shields/safety goggles/safety glasses, overalls and/or a cryogenic rated apron, and sturdy covered shoes should be worn to ensure cryogenic material does not come into direct contact with the body.

(11) Explosion from expanding vapours – Sealed containers should not be used to store either LN or dry ice and any sample containers used must be fit for purpose.

(12) When cryopreserving samples, tubes should be kept upright at all times and the precautions taken to ensure the thread of the tube cannot be submerged in the LN. Tightening of lids on tubes into which LN has leaked in to inadvertently may cause the tube to explode. Specifically designed cryopreservation racks can be purchased which will may reduce the chance of this occurring.

(13) Pouring of LN or dry ice into the drains should be avoided as contact with water will increase the rate of gaseous products and the reduced temperatures may damage the drainage pipework.

(14) All bulk deliveries of dry ice or liquid nitrogen should be moved with the assistance of mechanical aids such as trolleys. Assisted lifting (using multiple people) should be considered for loading trolleys or pouring copious quantities of liquid nitrogen.

(15) Embrittlement - carbon steel, plastics and rubber become brittle and fracture under stress when exposed to cryogenic temperatures. Storage vessels should be checked regularly for cracks and leaks and be replaced as required.

(16) Additional Risk for LN. Since the boiling point of LN is lower than liquid oxygen, oxygen enrichment can occur within areas of the LN storage system (such as cold traps). Organic material should be kept away from these areas to minimise the risk of fire or explosion. Cycling the temperature of the trap will allow accumulated liquid oxygen to boil away.

Storage and transport

Dry ice

(17) Styrofoam eskies are suitable for small quantities (less than 500g) of dry ice used to transport biological samples. Larger quantities of dry ice should be stored in purpose-built, vented eskies to reduce the rate of off-gassing of carbon dioxide gas. Small amounts of dry ice, e.g. a single esky of biological samples, may be transported in lifts without special precautions, as well as in vehicles provided adequate ventilation is maintained at all times.

(18) For dry ice quantities above 500g, a utility vehicle with a load area segregated from the passenger compartment will be suitable regardless of the container type. The transport requirements for larger quantities in vehicles with shared load and passenger compartments will need to be determined by a risk assessment.

(19) Consideration should also be given to the substitution of dry ice for road transport of perishable samples with a method that does not pose an asphyxiate gas risk. This includes:

a. Transport with a refrigerated cooler brick, gel, or wet ice if the samples are sealed from water intrusion.
b. Lyophilisation (freeze drying) of the samples where morphological properties do not need to be retained.

Liquid nitrogen

(20) LN should be stored and transported in containers specifically designed to contain cryogenic fluids. Container requirements are outlined in AS 2243.2 and AS 1894.

(21) All LN containers should be stored:

a. in a stable manner and on a sturdy surface; and
b. in a position that does not restrict access and egress; and
c. in a position where they are unlikely to be knocked by persons or other equipment.

(22) LN - Oxygen Depletion Calculations should be carried out for each workplace used for storage and handling of liquid nitrogen.

(23) If the oxygen concentration in the laboratory is:

a. Greater than 19.5% - acceptable.
b. Between 18% and 19.5% - unacceptable. Controls should be implemented to increase oxygen concentration - increase ventilation and decrease the volume of liquid nitrogen used in the laboratory. A low oxygen alarm should be installed.
c. Less than 18% - unacceptable. No UQ worker should enter the room. Only emergency services personnel with air supplied breathing apparatus should enter this environment. Whilst the room is at this concentration, control measures must be implemented to prevent entry to the space. Such controls could include for example, interlocks on the doors of large liquid nitrogen dewar storage areas that are activated by the oxygen monitor detecting a low oxygen atmosphere (caused by an accidental release of asphyxiant gas).

(24) Regardless of oxygen concentration, UQ requires rooms containing more than 50 litres of LN (whether in pressurised vessels or dewars) should have a low oxygen alarm fitted the event of liquid nitrogen spills, and liquid or gas escapes.

(25) Specific ventilation controls include:

a. Vents and relief valves of pressurised liquid nitrogen vessels should discharge to a safe place (not impinge on people, plant, or structures) and should be connected to an extraction system that exhausts to a safe external location or recovery system.
b. Where processes generate significant quantities of nitrogen gas, extraction ventilation should be used to remove nitrogen gas from areas where it can affect persons and exhaust it to a safe external location or recovery system.

(26) Lifts and enclosed spaces:

a. For relocating LN dewars within and between buildings, a dewar on wheels or suitable trolley should be used. Goods or passenger lifts can be used to move containers between floors provided they are not accompanied, and that control measures are in place that prevents a person from getting into a lift with the container, for example, a lift lock-out mechanism.

b. If containers of LN are to be transported by vehicle, a dry shipper (purpose-built vacuum flask that allows no LN to be spilt) should be used. Under no circumstances should LN be transported in an enclosed vehicle.

Part B - Training and competency

(27) UQ workers working with liquid nitrogen or dry ice should complete the online training module Liquid Nitrogen and Dry Ice Safety via Workday (staff and HDR students) or Blackboard.

Part C - Spills and contamination

(28) If a low oxygen alarm is activated, the room should be evacuated immediately. Do not allow re-entry to the area. Call Security and the Work Health and Safety Coordinator WHSC/Safety Manager for the area.

Part D - Health effects and symptoms

Routes of exposure

(29) Routes of exposure include:

a. Skin contact.
b. Inhalation.

Local Health Effects

a. Cryogenic Burns
b. Asphyxia

Part E - Emergency procedures

First aid/medical treatment

(30) First aid equipment and first aiders able to treat Cryogenic burns and asphyxiation should be readily available to the work area.

Section 4 - Roles, responsibilities and accountabilities

Supervisors

(31) Ensure risks are identified and eliminated or minimised as far as reasonably practicable through the risk assessment process and that the risk assessment is completed in UQSafe.

(32) Provide supervision and training in the safe use of these materials.

(33) Supervise UQ workers in their area of responsibility when these materials are used, stored and transported.

(34) Provide appropriate safety systems and equipment and that they are fully operational and used correctly.

(35) Ensure all incidents, hazards and near misses involving these materials are reported in UQSafe and are investigated as soon as possible and that corrective actions (including review and modification of risk assessment and SOPs) are implemented to prevent recurrences.

UQ Workers

(36) Be aware of the risk assessments in the use, storage and transport of these materials and follow any safe operating procedures and use the controls outlined in the risk assessment.

(37) Assist with the risk assessment process to help ensure the assessment is comprehensive and accurate.

(38) Wear all PPE required and ensure it is maintained in good condition.

(39) Immediately stop work and notify the Supervisor if there are any changes to procedures or deficiencies in the work process or risk assessment, and

(40) Report all incidents, hazards and near misses in UQSafe.

Section 5 - Monitoring, Review and Assurance

(41) Organisational Heads and Supervisors should regularly review the effectiveness of local procedures, and guidance material, particularly following incidents and near misses.

(42) Health, Safety and Wellness Division will review this Guideline as required to ensure its accuracy and relevance and will amend as appropriate regarding feedback on its effectiveness. As part of normal assurance monitoring, the Health, Safety and Wellness Managers may periodically assess the:

a. Existence and adequacy of workplace risk assessments;
b. UQ workers' compliance with local procedures in the workplace; and
c. UQ workers' awareness of compliance obligations associated with this Guideline.

Section 6 - Recording and Reporting

(43) UQ workers report in UQSafe any incidents, hazards or near misses.

(44) Risk assessments will be completed in UQSafe.

Section 7 - Appendix

(45) Asphyxia - the condition that arises when the blood is deprived of an adequate supply of oxygen.

(46) Cryogenic liquid – a liquid having a normal boiling point below −90°C at atmospheric pressure (101.3 kPa).

(47) Dry ice – Solid carbon dioxide which sublimates from a solid to a gas at temperatures above -78.5°C (atmospheric pressure).

(48) Dewar – double-walled and vacuum-insulated container used to hold cryogenic liquids. Dewars can range widely in size and may take several different forms, including, open flasks, atmosphere storage containers with loose fitting lids and self-pressurising tanks.

(49) Liquid nitrogen (LN) – molecular nitrogen in a liquid state which boils to given gaseous nitrogen at a temperature of −196 °C (atmospheric pressure).

(50) UQ workers – for the purposes of this procedure includes:

a. staff - continuing, fixed-term, research (contingent funded) and casual staff
b. contractors, subcontractors and consultants
c. visiting academics and researchers
d. affiliates - academic titleholders, visiting academics, emeritus professors, adjunct and honorary titleholders, industry fellows and conjoint appointments
e. higher degree by research students, and
f. volunteers and students undertaking work experience.

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