OCDEM, Churchill Hospital, Oxford OX3 7LE

RA number: OCDEM RA 1

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Risk assessment

Use and Handling of Liquid Nitrogen in OCDEM

Liquid nitrogen is a colourless, odourless liquid with a boiling point of -196°C at atmospheric pressure, a density of 0.8 kg/L and a very low viscosity. As the liquid changes to gas, which it does rapidly at ambient temperature and pressure, the expansion ratio is approximately 700. The resulting cold gas is heavier than air, so it accumulates at low level.

This risk assessment must be read in conjunction with OCDEM SOP S6 'Code of Practice for Handling of Liquid Nitrogen in OCDEM' and University Policy Statement S4/03.

Persons at risk

Persons filling vessels from the manual fill point.
Persons decanting from 25 litre Dewars into smaller flasks.
Persons using liquid nitrogen for snap-freezing.
Persons storing samples in cryostores.
Persons retrieving samples from cryostores.

Potential hazards, control measures, recommended action

The hazards of liquid nitrogen are largely related to the volume of gas produced on evaporation and to the liquid's low temperature. Its very low viscosity means that it rapidly and completely covers surfaces on which it is spilt and it easily penetrates cracks and voids.

The alarm should not be activated when storing or removing samples, the venting system should pull through sufficient air to keep the oxygen level at 20%; the majority of alarm situations arise when using the manual fill tap.

Asphyxiation

Hazard

On boiling, liquid nitrogen produces approximately 700 times its volume of gas. The resulting displacement of oxygen from the atmosphere may be sufficient to cause asphyxiation. There is no preliminary warning by the individual of oxygen deficiency caused by the addition of nitrogen. Asphyxiation is usually sudden; the lack of oxygen content causes immediate collapse into a layer of dense, cold nitrogen-enriched air. Unconsciousness followed rapidly by death is inevitable without immediate rescue and resuscitation. Rescue attempts often result in the rescuers being overcome as well.

Smaller leaks or spills, or normal boil-off from liquid nitrogen containers in confined spaces, may be sufficient to reduce the oxygen content and carry the risk of asphyxiation.

Degrees of asphyxia will occur when the atmosphere contains less than 20.9% oxygen by volume. Exposure to an atmosphere containing less than 18% oxygen poses a significant risk. When the oxygen concentration in the air is sufficiently low, a person can become unconscious without sensing any warning symptoms, such as dizziness. There is a risk of death when the oxygen level falls below 11%.

Control measures

1. A low level extract system is installed to exhaust the nitrogen gas to the atmosphere, where it dissipates.
2. Users are trained in the correct procedures for manual filling, topping up levels in the vessels that do not fill automatically, storing and retrieving samples and to minimise spills. They are also trained in emergency procedures.
3. A system of work stipulates a ‘buddy system’ for manual filling, any decanting of liquid to smaller flasks or transport vessels, topping up storage vessels and during the storage or retrieval of samples.
4. Access into the area is restricted to authorised users by swipe card; access is only permitted after the mandatory training has been received.
5. Large capacity supply vessels and LN_2 refrigerators are routinely kept locked.
6. The door to the room is propped open when occupied to allow for rapid egress.
7. An oxygen depletion monitor is installed. The oxygen detection system has two sensors on two sides of the room; the system is set to alarm at 19.5% O_2 and 18% O_2 levels; the visual panel is located outside the room and the oxygen content reading alternates between the two sensors. At both alarm levels the siren will sound in the room and the beacon will flash in both the room and the hospital corridor. At 18% oxygen the shut off valve on the external tank will activate, shutting off the supply; this valve will reopen when the O_2 levels have returned to 20% and the control panel is reset.
8. Two emergency cut-off valves have been installed for emergency use, one inside the room and the other outside the room above the oxygen detector control panel.

Action

When the oxygen content decreases to 19.5%, the alarm will sounds and the beacon in the room will flash. Leave the room until the oxygen returns to 20% or more on the panel; press the reset button briefly to silence the alarm. It should only take a few seconds for the level to return to 20%.

When the 18% alarm sounds (the siren speeds up as well as the automatic shut-off valve activating); leave the area immediately and shut the door behind you. This enables the venting system to work more efficiently and return the oxygen level to 20% more quickly. When the oxygen level has returned to 20% or greater press the reset button for about three seconds to reset the shut-off valves and silence the alarm.

If the oxygen level does not return to 20% within 15 seconds ensure that the area is secured to prevent other users from entering and send the ‘buddy’ to contact the DSO or one of the lab managers who will assess the situation and either inform when the area is safe to re-enter or take further action.

If the decreased oxygen level is caused by a leak of liquid nitrogen and the automatic shut–off has failed, immediately press one of the emergency cut-off buttons.

If asphyxia occurs immediately move the affected person to the open air if it is safe for you to do so. Keep victim warm and rested. Call an ambulance. Apply artificial respiration if necessary.

However, attempts to rescue affected persons from confined spaces or where an oxygen deficient atmosphere may be present should only be made by those trained in the use of breathing apparatus and confined space entry procedures. The Fire Brigade should be called in all instances where a trapped person requires rescue.

Cold burns and frostbite

Hazard

Skin contact with liquid nitrogen or cold nitrogen gas may cause severe cold burns and prolonged exposure, may result in frostbite. Unprotected skin may freeze onto surfaces cooled by the liquid causing severe damage on removal.

Splashes of liquid nitrogen or short exposures to cold vapour or gas to the eyes may cause instant freezing of eye tissue and permanent damage.

Prolonged inhalation of cold vapour or gas may cause serious lung damage.

Control measures

When handling liquid nitrogen the following are required:

1. Eye protection – as a minimum safety spectacles with side shields, preferably one of the provided full face-shields. During manual filling and retrieval of samples from liquid phase, a face shield to EN 166 **must** be worn
2. Hand protection – non-absorbent, insulated gloves to EN 511 or loose fitting leather gloves must be worn. Gloves are not intended to protect the hands against immersion.
3. Foot protection – open-toed shoes must not be worn.
4. Clothing –. A splash resistant apron must be worn if there is a risk of splashing and when using the manual fill tap. A lab coat or overall must be worn when storing or retrieving samples.

Action

First Aid Measures:

Skin Contact - immediately flush thoroughly with water for 15 minutes. A first aider must assess all cold burns and medical assistance needs to be obtained to assess the extent of tissue damage for deep burns or if blistering occurs. In case of frostbite spray with water for at least 15 minutes, apply a sterile dressing and obtain medical assistance.

Splashes into the eye – flush with running water for at least 15 minutes. Take the casualty to the Eye Hospital for assessment.

Explosion due to trapped gas

Hazard

If liquid nitrogen is trapped inside a sealed container, then expansion on warming may cause an explosion or will force the lid from a cryovial under pressure, giving rise to danger from contamination from the vessel's content as well as injury from fragments of the vessel itself.

This can arise, for example, if an incorrect vacuum flask is used or sample cryovials have been immersed in liquid nitrogen.

Control measures / Action

1. Only vessels designed for liquid nitrogen must be used. Glass domestic vacuum flasks must not be used for liquid nitrogen.

2. A full face shield must be worn during manual fill operations and when retrieving samples from liquid nitrogen, regardless of the phase in which they are stored.
3. All samples should be stored in vapour phase if possible and any new samples **must** be stored in vapour phase. On removal all samples must be placed into a secondary container with a closed lid immediately (eg sandwich box, larger tube) to warm up, regardless of the phase in which they are stored. Preferably, archived samples stored in liquid phase, should be moved to vapour phase storage for at least 24 hours before retrieval; if samples are removed from liquid phase they must be replaced into vapour phase.

Explosion due to condensation of liquid oxygen

Hazard

Liquid oxygen may condense in open containers of liquid nitrogen; the presence of liquid oxygen may give rise to explosions caused by increased pressure if the vessels are later sealed and allowed to warm up.

Control measures

Open vessels should be avoided where possible.

For more comprehensive information on liquid nitrogen use read 'University Policy Statement S4/03. This is available at: http://www.admin.ox.ac.uk/safety/.

Update history

Version	Date	Reason for update	Updated/reviewed by :	Date next review due
1	Jan 2005	New Risk assessment	CD/SMH	Jan 2007
1a	Sep 2007	Changes to safety personnel	SMH	Sep 2009
1a	Oct 2009	No changes	SMH	Oct 2011
2	Jun 2011	Minor changes to text and Head of Safety	SMH	Jun 2013
2.1	June 2013	Change to Header; addition of text to cover emergency shut off valves, other minor wording changes.	SMH	June 2015
2.2	10 August 2015	Reviewed – slight changes to wording on retrieval of samples.	SMH	August 2017