C_004A – Cryogenic Liquids Safety Training

Outline

The purpose of this training is to familiarize workers with:

- **Hazards of liquid and gaseous cryogenics**
- **Common uses of cryogenics at LLE**
- **Appropriate handling of cryogenics**
- **Fixed and portable oxygen monitors**
- **Administrative controls**
- **Emergency response procedures**

Required participants:

- **Anyone handling cryogenic materials at LLE**

Prerequisites:

- **C_001 Chemical Safety Training**
- **M_001 Mechanical Safety Training**
- **M_002 Compressed Gas Safety Training**

Additional training:

- **C_004 (High-pressure Liquid Nitrogen (LN_2) fill station certified operators)**

On Jan. 28, 2021, in Gainesville Georgia, six workers died as a result of a liquid nitrogen release into the workplace

- **The U.S. Department of Labor's Occupational Safety and Health Administration investigated the incident and found:**

  The *employers failed to implement safety procedures necessary to prevent the nitrogen leak, or to equip workers with the knowledge and equipment that could have saved their lives.***

- **OSHA cited a total of 59 violations and proposed $998,637 in penalties.**
- **LN_2 is an invisible hazard that displaces oxygen and can cause *permanent injuries or death.***

Liquid nitrogen and other cryogenic materials *must* be handled with extreme caution and only by qualified users.

* https://www.osha.gov/news/newsreleases/national/07232021

* https://www.csb.gov/assets/1/6/ffg_investigation_report_publication_copy.pdf

Cryogenic liquids freeze living tissue rapidly on contract and can cause asphyxiation by oxygen displacement

- **Direct contact of unprotected tissue with liquid nitrogen (LN_2) (77°K, -321°F) can cause serious and very painful *cryogenic burns* within seconds**

- **LN_2 expands ~700 X its liquid volume as it reaches room temperature, rapidly displacing oxygen and potentially causing an oxygen deficient atmosphere**

- **An oxygen-deficient atmosphere can be debilitating, and in extreme cases can cause long lasting health effects or be *lethal after a brief exposure***

LN_2 must be stored, handled and transported using specialized equipment and proper Personal Protective Equipment (PPE)

Humans begin to suffer adverse health effects immediately when oxygen concentration in air drops below 19.5%

OSHA - Oxygen Deficient Atmosphere Risk Summary

< 19.5%	Air is oxygen deficient
16 - 19.5%	Increased breathing rates, accelerated heartbeat, impaired thinking or coordination. Momentary loss of coordination may be devastating to workers performing dangerous tasks
12 - 16%	Increased breathing rates,, accelerated heartbeat, impaired attention, thinking and coordination
10 - 14%	Faulty judgement, intermittent respiration and exhaustion felt with minimal exertion
6 - 10%	Nausea, vomiting, lethargic movements and likely loss of consciousness
< 6%	Convulsions, then apnea (cessation of breathing), then cardiac standstill. Symptoms occur immediately and can cause irreversible organ damage; death occurs in ~ 8 minutes

Administrative controls

An oxygen monitor is the *only* way to detect an oxygen-deficient atmosphere

- LLE personnel are not permitted to enter or work in an O_2 deficient atmosphere
- An oxygen monitor must be used when engineering controls can't eliminate the risk

- Personal monitors are suitable for temporary or short-term uses
- Must be worn by at least one individual during room occupancy (return to holder upon exit)

- Fixed (permanent) monitors are required where the hazard is persistent

Exit the area immediately if an O_2-deficiency alarm is activated.

Door signs alert personnel to area hazards and provide guidance on appropriate response to emergency situations

Some permanent O_2 monitors emit an audible signal only.

Others also have a beacon and/ or a lighted sign mounted remotely from the sensor

Read and be aware of the signs for your work area.
Do not enter if a sign is flashing OR if an alarm is audible

Liquid nitrogen and other cryogens (i.e. helium) are used frequently at LLE to cool equipment, targets, samples and detectors

- Large volumes of LN_2 (60 liters and above) are transported from the high pressure LN_2 fill station at the West loading dock to laboratories and work areas within LLE
- Application areas include the cryo target filling and tritium recovery facility (Rms. 156A, 156B, 157, 2838) and the Materials Chemistry laboratories (Rms 112B and 115)
- The high pressure LN_2 fill station is supplied by a a large LN_2 supply tank (owned and maintained by Airgas) located outside the West loading dock

All new LN_2 use setups must be reviewed by LLE Safety Officers *before use* to ensure risks of cryogenic burns and oxygen-deficient work atmospheres have been fully mitigated

The mode of transportation for cryogens depends on the volume of liquid to be transported

Ambient-pressure Dewar flasks (< 5 L)

- Open-top insulated containers purpose-made for transporting and containing cryogenic fluids
- Can be made with a metal or HDPE outer shell with an insulating material (solid insulation or vacuum jacket
- Must have a vented cover to release pressure and prevent splashing of liquid while transporting
- Vacuum-jacketed glass Dewar flasks can implode if filled too rapidly with cryogenic fluids

Consumer-grade “Thermos” bottles must NEVER be used for cryogen dispensing and transport! (no pressure relief mechanism)

The mode of transportation for cryogens depends on the volume of liquid to be transported

Pressurized cryogen storage containers (≥30 L)

- Designed and engineered specifically for transporting, storing and dispensing larger volumes of cryogenic liquids
- Operating pressure maintained by cryogen evaporation using two separate PRV valves (or one PRV and one rupture disk)
  - First-stage PRV (operating pressure): ~20 psi
  - Second-stage PRV (overpressure) : ~35 psi
- Small losses of gas pressure from the PRV (hissing) are normal due to slow evaporation of LN_2
- DO NOT modify or shut off any PRV's or rupture disks!

Users who fill *pressurized* LN_2 storage vessels must complete C_004: High Pressure Liquid Nitrogen Fill Station training

Only personnel that have completed appropriate training are permitted to work with cryogenic liquids

- Do not use liquid nitrogen for applications not previously approved
- Only use containers specifically designed to hold liquid nitrogen
- Carry cryogenic liquid containers and away from body
- Open-top containers must be covered during transport to prevent splashing of cryogenic liquid

Proper clothing and PPE needs to be worn during transport, not just when conducting laboratory experiments

Appropriate personnel protective equipment (PPE) is required when handing any amount of cryogens

High pressure LN_2 fill station (pressurized containers)

Goggles, face shield and hearing protection

Long sleeves and insulated gloves

Insulated apron

Full length pants, with no cuffs and insulated foot covers over close toed shoes (hiding under the apron)

Ambient pressure transfers in laboratory applications

Insulated gloves

Goggles

Lab Coat

Full length pants, with no cuffs and close toed shoes

(This photo was staged; no LN_2 was used or poured down the drain)

Safe transfer of LN_2 from a pressurized storage tank to a small portable cryogenic containers (<10 L)

- **Before transferring, be sure the container has been designed specifically for cryogenic liquids**

No Styrofoam coffee cups or other "home-made" transfer vessels

- **Transfer only in a well-ventilated area**
- ***Pour slowly* to prevent splashing and temperature shock implosion with glass vacuum-jacketed Dewar flasks**
- **Always pour cryogens at or below shoulder level**
- **Maintain a good grip on the vessel throughout the transfer**

Emergency response

Large-scale cryogen leaks or personnel exposure require a rapid, coordinated response

Large spills, oxygen monitor alerts

- Evacuate the area IMMEDIATLY
- Seek a well-ventilated area
- Contact the work area supervisor or Responsible Individual on door sign
- Shut off the LN_2 supply, if possible to do so from outside the affected area

Medical emergency

- Call LLE's Medical Emergency Response Team (or 911 if off-hours).
- Clearly state that the area is Oxygen deficient when contacting emergency responders

Eye/skin exposure

- Alert the LLE Medical Response Team immediately
- Flush exposed area with lukewarm water for 15 minutes, seek medical attention for additional treatment and assessment
- Report any employee injuries to the work area supervisor and LLE HR Admin ASAP

Before receiving credit for this training you must:

Successfully complete* the C_004A quiz to satisfy your training requirement

***If this is your first time taking this training topic, follow the instructions in your quiz confirmation email to meet with a Subject Matter Expert before receiving credit**