SAFE HANDLING AND USE OF LIQUID NITROGEN

- **REQUIRED TRAINING FOR ALL LIQUID NITROGEN USERS AT NF/SG VHS**
- Industrial Hygiene and Research Service

PURPOSE & DEVELOPMENT

This safety training is for general liquid nitrogen (LN_2 or LN2) use as well as container filling, management and transport. NFSGVH Research Service adopted this training from Purdue University, Department of Radiology & Environmental Management (RU-REM) who developed the training from safety regulations, risk analysis, manufacturer recommendations, best practices, and lessons learned from LN_2 users. We would appreciate any comments and feedback from our LN_2 users on how this training can be improved. Please forward any comments or feedback to:

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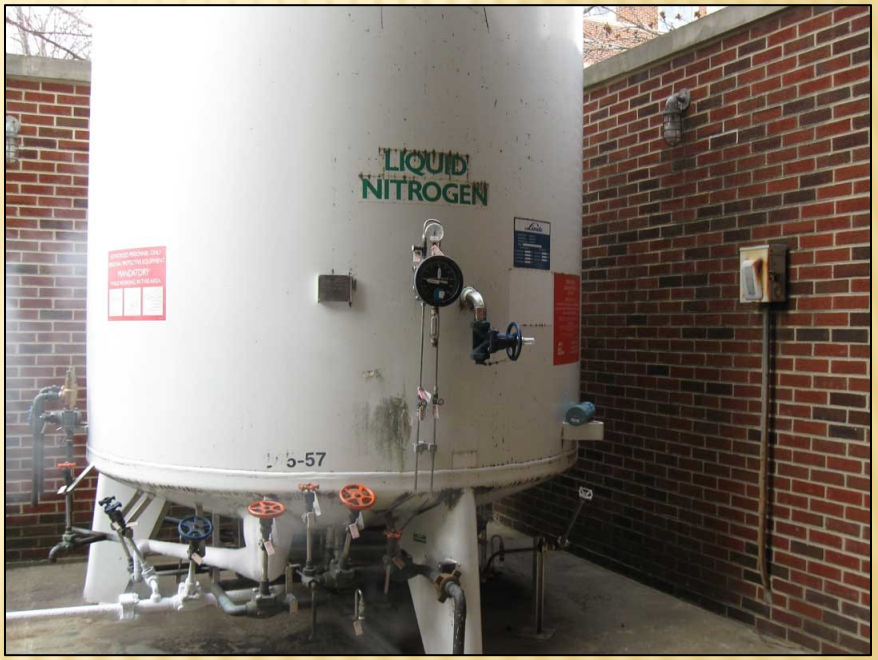
TRAINING OUTLINE

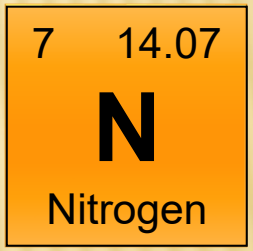
- Characteristics and Hazards
- Personal Protective Equipment
- Exposure
- Containers
- Safety Procedures
  - General Use and Storage
  - Container Filling Procedures
  - Container Labeling
  - Container Closure
  - Container Handling and Transport
  - Container Troubleshooting
- Questions



CHARACTERISTICS & HAZARDS

CHARACTERISTICS

- Nitrogen (N_2) is 78% of the Earth's atmosphere
- N_2 is colorless, odorless, tasteless
- N_2 boiling point is -196 ºC (-320 ºF)
- N_2 gas is slightly lighter than air
- N_2 gas will not support life



HAZARDS

- Cryogenic liquid that can cause severe frostbite or eye damage upon contact.
  - Liquid nitrogen is liquefied by cooling nitrogen gas down to (or below) its boiling point [-320°F (-196°C)]. Neither the liquid nor the vapor is flammable.
- Substances may become brittle upon contact with LN_2 and shatter.
- Expands by a factor of 700 upon vaporization
- May cause explosion of a sealed container

HAZARDS (2)

- Can Cause Asphyxiation
  - LN2 should be used and stored in well ventilated areas
  - High concentrations of nitrogen displaces oxygen reducing the breathable oxygen in the air.
  - Asphyxia can develop slowly as the oxygen content of air is reduced below 21%.
  - The victim may not recognize the symptoms of gradual asphyxia from decreasing oxygen levels.
  - Oxygen monitors are a best management practice in work/storage areas that use large volumes of LN_2.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

PPE – EYES

- ANSI approved safety goggles and full face shield are recommended when handling over 100 mL of LN_2.
  - Safety glasses do not provide adequate protection from potential splash hazard of large quantities.

PPE – HANDS

- Cryogenic gloves are required when
  - Dispensing from LN_2 container containing greater than 100 mL
  - Handling LN_2 quantities greater than100 mL

PPE – BODY & FEET

- When handling LN_2 quantities greater than 100 mL
  - Fully enclosed shoes are required (no open-toe or canvas shoes, sandals, or clogs)
  - Long pants and long sleeve shirt or lab coat (no shorts or short-sleeved shirts)

PPE – GENERAL USE

The supervisor is required to complete the hazard assessment for all PPE-appropriate work activities. Responsible recommendations are:

- For small quantities, safety glasses and lab gloves are adequate. Wear closed toed shoes.

- For intermediate quantities (100 mL to 1 L), use splash goggles, face shield, and cryogenic gloves. Wear closed toed shoes.

PPE – LARGE VOLUME TRANSFERS

- For transfers larger than 1 L or filling a larger secondary Dewar, a cryogenic apron should be used in addition to the general use intermediate requirements.

EXPOSURE

EXPOSURE – SKIN CONTACT

- **Skin contact can cause severe cold burns and frostbite.**
  - Flesh freezes very rapidly, flesh may be torn attempting to be withdrawn from object
  - If frostbite or freezing occurs, the following steps should be taken:
    1. Flush area thoroughly with tepid water
       - Do not apply direct heat
       - Do not rub affected area
    2. Protect area with bulky, dry, sterile dressings
    3. Seek medical attention (dial 911 if necessary)
    4. Notify supervisor

EXPOSURE – EYE CONTACT

- Eye exposure can cause permanent irreversible damage
- Delicate eye tissue can be damage by exposure to the cold gas alone
- If liquid is splashed into eyes, do the following:
  1. Flush with water for 15 minutes
  2. Seek medical attention (Emergency Dept)
  3. Notify supervisor

EXPOSURE – ASPHYXIATION

- With asphyxiation, unconsciousness may happen without warning
- If person becomes dizzy move them to well-ventilated area
- Seek medical attention (Emergency Dept)
- Notify supervisor

CONTAINERS

TYPES OF CONTAINERS

- **Vacuum Insulated Containers:** used for storing and dispensing LN_2; either sealed (capable of holding a 20 psig – 240 psig with pressure relief valves) or ambient pressure (covered loosely with a cap, cork, or stopper); called **Dewars** (due'-werz) no matter the size
  - Dewar Flasks/Thermoses



  - Self-Pressurizing Tanks


- **Non-Insulated Plastic Containers:** used for cryogenic storage
  - Cryogenic tubes and micro-tubes/vials/canes (plastic or metal)

BENCH-TOP DEWARS

- Typically for small-scale laboratory use
- Lid is only pressure relief device
- Nitrogen exposure risks are primarily during filling and transporting

LARGE DEWARS

- Typically used for one of the following:
  - Storage of small samples in the laboratory
  - Movement of samples between campus locations
  - To fill other secondary containers
- Dewars may have a secure seal and pressure relief vent
- Exposure risks are primarily during filling and transporting

CRYOGENIC TUBES & VIALS

- Typically utilized for one of the following:
  - Samples storage in the laboratory under LN_2
  - Sample movement between campus locations
  - Sample shipments for collaborative research

- No pressure relief device other than the container lid

- **Cryotubes can explode without warning:**
  Explosions are likely caused by trapped nitrogen expanding inside the cryogenic tube or vial during the thawing process. As the temperature increases the tube or vial may become over pressurized and explode. Serious injuries (e.g. plastic embedded in eyes or skin) have been reported.

CRYOGENIC TUBES & VIALS (2)

- Due to high risk of explosion when thawing cryogenic tubes and vials:
  - Wear a face shield and goggles
  - Wear heavy gloves
  - Wear a buttoned lab coat over pants or long skirt
  - Wear closed toed shoes
  - Place the tube or vial in a heavy-walled container (e.g., a desiccator) or behind a safety shield during thaw.

SELF-PRESSURIZING TANKS

- Generally a 140 – 260 L double wall stainless steel tank
- Used to fill other LN_2 containers and used in many industrial processes
- Equipped with pressure relief valve(s) and backup rupture disk
- Loud hissing sound common when pressure relief valve opens
- Exposure risks can occur:
  - Connecting and disconnecting equipment
  - During fill processes
  - From leaking valves
  - From condensate ice buildup on valves and hoses
- Sprains/strains/broken bones not uncommon. Always use two people when moving and be cautious.

SELF-PRESSURIZING TANKS – VALVES

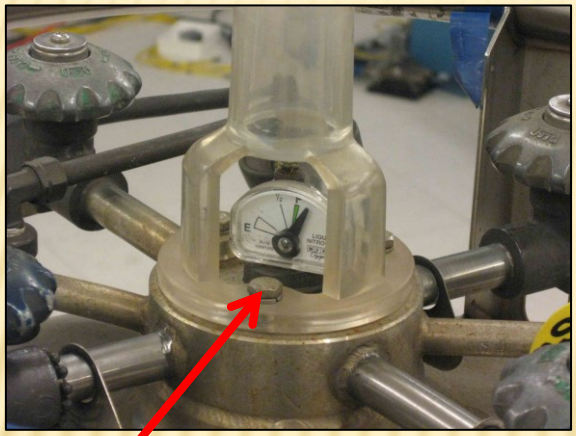
- The liquid connection valve should be opened slowly to minimize the thermal affects and cryogenic hazards from the tank, hoses, and valve exteriors.

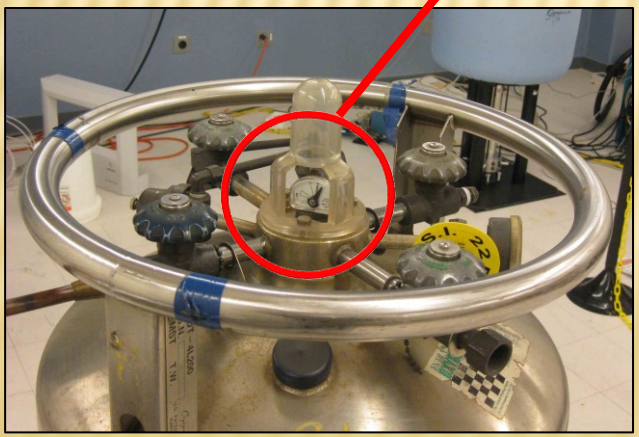
SELF-PRESSURIZING TANKS – GAUGES

- The pressure gauge is not a reliable indicator of pressure due to high failure rate from LN_2 exposure.

SELF-PRESSURIZING TANKS – GAUGES (2)

Needle Gauge





Float Type Sight Gauge

PHASE SEPARATOR

The phase separator is used on the fill hose during the filling process to minimize the splash hazard and to maintain better flow control of material.

SAFETY PROCEDURES

GENERAL SAFE USE PRACTICES

- Only trained personnel should work with LN_2
- Have a procedure when working with LN_2; procedure should include:
  - Use only in well ventilated and low traffic areas
  - Caution signs should be posted in the area warning that LN_2 is being stored and used
  - Wear appropriate PPE
  - LN2 should only be handled in approved containers
  - Avoid breathing LN_2 vapors
  - Carry containers away from body and face
  - Do not leave open containers unattended

STORAGE PRACTICES

- **Containers must be stored:**
  - In cool, dry, and well ventilated areas
    - DO NOT store in a cold room or other controlled environment room without air supply
  - Out of direct sunlight
  - In an area with signage indicating cryogenic material storage

FILLING CONTAINERS

- Check LN_2 container prior to each fill for cracks or problems with container.
  - Large Dewar (25 L) must be checked at least annually.
- Do not overfill Dewar or secondary containers.
  - Check manufacturer or supplier recommendations for fill weights.
  - Overfilling can cause container failure due to over pressurization or damage to pressure relief device.
- Never pour LN_2 out of pressure relief device, this can damage the O-ring of the pressure relief device.
- Transfer slowly to prevent splashes and thermal shock to container.
- Point rupture disk and pressure relief valve away from people.

FILLING CONTAINERS (2)

Proper procedure for filling a non-pressurizing bench top container from self-pressurizing or non-pressurizing Dewar or other secondary container.

Ensure the phase separator is INSIDE the secondary container.

CONTAINER CLOSURE

- Ensure containers are closed properly.
- Never attempt to repair or modify a rupture disk or valve. Contact manufacturer for replacement.
- Improper LN_2 container closure can lead to:
  - Over pressurization from LN_2 getting between inner and outer container
  - Spill and possible LN_2 exposure
  - Lid damage or changes
  - Complete container failure or rupture

IMPROPER CONTAINER CLOSURE

- Never use something other than manufacturer's cap for closure. **Aluminum foil is not acceptable.**
- Never modify or remove the lid's foam.
- Never leave lid resting on top of container to allow pressure to escape.

CONTAINER HANDLING & TRANSPORT

- Containers vary in size and weight; they may be heavy and/or cumbersome.
- Dewars more than 100 lbs. require two people to move safely.
- Never drop a LN_2 container. Damage to a container may result in over pressurization or container failure.
- Never attempt to stop or catch a falling container.
- Always use a specially designed cylinder cart to transport LN_2 containers too heavy or large to be hand carried.
  - Do not transport in uncovered containers.
  - Do not roll containers on their sides or while in upright position.
- Use the freight elevator whenever possible.

TROUBLESHOOTING CONTAINERS

- **Issue:** Container is covered with frost
- **Possible Cause:** Vacuum integrity compromised
- **Recommended Action:** If accompanied by a high rate of product venting through the safety relief valve, or high rate of pressure increase, call container supplier or manufacturer

TROUBLESHOOTING CONTAINERS (2)

- **Issue:** Container has isolated spots of frost
- **Possible Cause:** Container may have been damaged, compromising integrity of insulation
- **Recommended Action:** Contact supervisor or call supplier for replacement

QUESTIONS

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If you have questions regarding LN_2, contact:

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