Safe Handling and Use of Liquid Nitrogen

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- This awareness training is intended for users of Liquid Nitrogen at the UC Davis Health System.
- The training covers Oxygen Deficiency, Handling of Liquid Nitrogen, Personal Protective Equipment, Emergencies, and Trouble Shooting.
- All laboratory and other personnel dispensing/using Liquid Nitrogen should review this information and refer to it periodically.

Topics to be Covered

- Physical and Chemical Properties of Nitrogen
- Characteristics of Cryogenic Nitrogen and Associated Hazards
- Handling Liquid Nitrogen
- Liquid Cylinder Construction
- Filling Cryogenic Dewars
- Proper Personal Protective Equipment (PPE)
- Safely Moving Liquid Cylinders

Topics to be Covered, con't

- Emergencies/Burn Hazards
- Elevator Transport
- Troubleshooting

Manufacture of Liquid Gases

- Normal air is cooled.
- As the temperature drops, the gases will drop out separately, according to their boiling points. Liquid nitrogen will drop out at –320°F (-196°C)
- The liquefied gas is collected.
- The liquid boils violently in trying to get back to its normal gaseous state.

Characteristics of Nitrogen

- 78% of Atmosphere
- Colorless, Odorless, Tasteless and Nontoxic
- Boils at -320 degrees Fahrenheit (-196°C)
- Non-Flammable
- WILL NOT SUPPORT LIFE
- Gas is slightly lighter than air

Oxygen Deficiency

- Liquid nitrogen, when returned to the gaseous state, can displace oxygen from the air and can create an oxygen-deficient atmosphere under the right conditions.
- It may be prudent to install oxygen monitors in areas where liquid nitrogen is stored and ventilation is minimal.

Characteristics of Oxygen

- Normal Concentrations:
  - The normal oxygen concentration in air is about 21% by volume. This provides for a safe working environment with respect to the oxygen required to support life.
  - Oxygen concentration below 19.5% is considered an oxygen-deficient environment

Characteristics of Oxygen Deficiency

- Physiological Effects:
  - Asphyxia develops slowly as the oxygen content of air is gradually reduced from 21%.
  - The victim will not be aware of a problem and generally will not recognize the symptoms of gradual asphyxia from decreasing oxygen levels.

Characteristics of Oxygen Deficiency

- Oxygen Deficiency Precautions:
  - All cryogenic liquids should be used and stored in well-ventilated areas.
  - High concentrations of nitrogen reduce the breathable oxygen in the air.
  - Filling between containers, leaking valves, and liquid tank venting are some examples that could lead to an oxygen-deficient atmosphere.

Characteristics of Liquid Nitrogen

- Primary Hazards
  - Asphyxiation
  - Potential for rupture of containers, pipelines, or systems. When liquid or even cold vapor is trapped between valves there is the potential to cause a pressure buildup to a point of violent rupture to a container or piping. (Reliable pressure relief devices are used to prevent this)

Liquid Nitrogen Facts

- Boiling Point -320°F (-196°C)
- Volume Expansion Rate = 696

Comparison to Other Liquefied (Cryogenic) Gases

Gas	N_2	O_2	Ar	H_2	He
BP, °F	-320	-297	-303	-423	-452
BP, °C	-196	-183	-186	-253	-268
Volume Expansion	696	860	696	850	745

Example:

- 1 cubic foot of liquid nitrogen will expand to 696 cubic feet of 100% gaseous nitrogen at 70°F
- The nitrogen gas can displace the oxygen in the area, leading to asphyxiation
- This is why cryogenic liquids must always be stored in well-ventilated spaces

Characteristics of Cryogenic Liquid Nitrogen

- Will not support combustion.
- Will not support life
- As a liquid it is non-magnetic

Handling Liquid Nitrogen

- Always read the container label prior to use
- Cryogenic liquid containers must always be stored in the upright position
- Cryogenic liquids must not be handled in open pail-type containers or in unapproved dewars.
- Transfer of liquid into warm lines or containers must be done slowly to prevent thermal shock and possible buildup of pressure.

Handling Liquid Nitrogen

- Precautions:
  - Always wear safety equipment, including heavy loose fitting leather or cryogenic gloves, and eye and face protection.
  - High concentrations of escaping gas should not be allowed to collect in an enclosed area.
  - Avoid prolonged breathing of cryogenic liquid vapors.

Handling Liquid Nitrogen

- Avoid rough handling of liquid containers
- A cold outside jacket indicates a loss of vacuum - Contact supervisor or vendor
- Liquid cylinders shall only be moved with proper handling equipment.

Handling Liquid Nitrogen

- Prior to use, ensure the fittings on the regulator match the fittings on the liquid container
- Never use adaptors
- Never attempt to change or remove any fittings other than connections for hoses

Containers for Holding Liquid Nitrogen After Dispensing

- Use only containers specially designed to hold liquid nitrogen - Check with the manufacturer of the container to ensure it is approved for holding liquid nitrogen

Different Types of Cryogenic Liquid Cylinders

Cryogenic Liquid Containers (aka Liquid Cylinders)

- Advantages:

  Contain large volumes of gas

  Provides a source of Cryogenic Liquids which can be easily handled

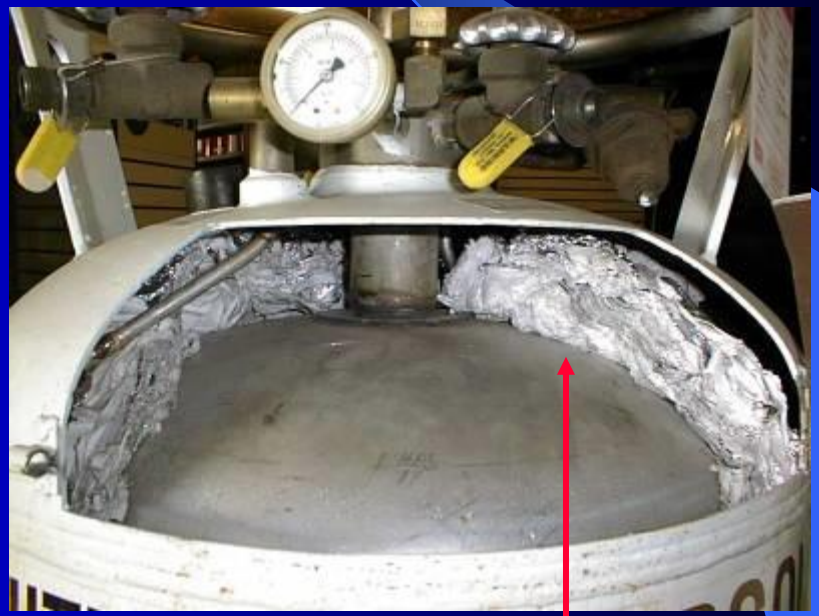
- Two general types:

  Low Pressure-For dispensing of liquid only.

  High Pressure-For dispensing of liquid and gas

Construction of Liquid Containers

- Liquid containers are made *somewhat* like Thermos® bottles with a vacuum space and special insulation, **but they are <u>not</u> Thermos® bottles**



Construction of Liquid Container

- Even with the vacuum and insulation, heat leaks in to the cylinder causing the cryogenic liquid to vaporize and build pressure.
- The vaporization rate will depend on several factors including the product itself, ambient temperature, condition of the cylinder's vacuum, etc.

Pressure Relief Devices

- The liquid-to-gas conversion rate is about 2.3% per day under perfect conditions, so the actual vaporization rate experienced can vary.
- If gas product is not used, pressure will build until it is released by a control valve.
- Note that this is a high pressure container, with the gauge marked for 350 psig.

Pressure Relief Devices

- Hearing a slight hiss from a liquid cylinder is usually the normal operation of its pressure relief device.
- Liquid cylinders should always be stored and used in areas with appropriate natural or mechanical ventilation.
- Never adjust, block, plug or attempt to repair anything on a liquid cylinder.

Liquid-to-Gas Conversion

- Since liquid is converted to gas at about 2.3% per day even under ideal container conditions, if the liquid is not used regularly, the vessel will be empty in a certain amount of time.
- It is important to estimate your use so the liquid will not be wasted.

Storage in Cold Rooms

- Contrary to popular belief, storage of liquid containers in cold rooms will not slow down the liquid to gas conversion.
- Storage in cold rooms can actually create an oxygen deficient atmosphere if the room does not have adequate ventilation to remove the nitrogen gas generated.
- **If there is a concern regarding oxygen deficiency in these areas, oxygen deficiency alarms should be installed in these areas.**

Cryogenic Liquid Containers (Liquid Cylinders)

- Always check the type of container that is being delivered or before use.
- One lab had ordered low pressure and received high pressure by mistake. The lab personnel assumed it was low pressure and began to use it. This could have resulted in an unsafe condition. Low pressure has an operating pressure of 22 psig!!!
- High pressure operates at 230 psig or above. Always check the pressure gauge to determine the type of container.

Liquid Containers are always inspected by the Vendor before and after filling

Items that are usually checked by the vendor before filling a liquid cylinder

- Visual Inspection
- Valve Inspection
- Pressure relief valve inspection
- Safety burst/rupture disc inspection
- Vacuum casing burst/rupture disk inspection
- Tare weight

Items that are usually checked by the vendor after filling a liquid cylinder

- DOT-4L markings
- Vent valve
- Gross weight
- Net weight

Content Gauge on Liquid Cylinders

The container **contents** gauge is a float-type liquid level sensor that indicates the level of the liquid.

The gauge is an indication of approximate container content, and should not be used for judging the weight of the container.

Containers are always filled by Weight!

Cryogenic Liquid Containers (Liquid Cylinders)

- Make sure you know the type of container that is used by your lab or unit!!
- Low pressure is used only for the delivery of LIQUID, not gas
- Its operating pressure is 22 psig

Cryogenic Liquid Containers (Liquid Cylinders)

- Caution signs should be posted in the area warning that liquid nitrogen is being stored and used.

Cryogenic Liquid Containers (Liquid Cylinders)

Head pressure

- Results when heat leaks into the container
- The safety valve will periodically release this pressure
- If the safety valve malfunctions, a backup disk will rupture and relieve the pressure
- The rupture of the backup disk will produce a loud sound and may release a large quantity of liquid and gas. *Evacuation of the area is required to prevent asphyxiation*

Low Pressure Liquid Container Components

- Liquid Withdrawal Valve

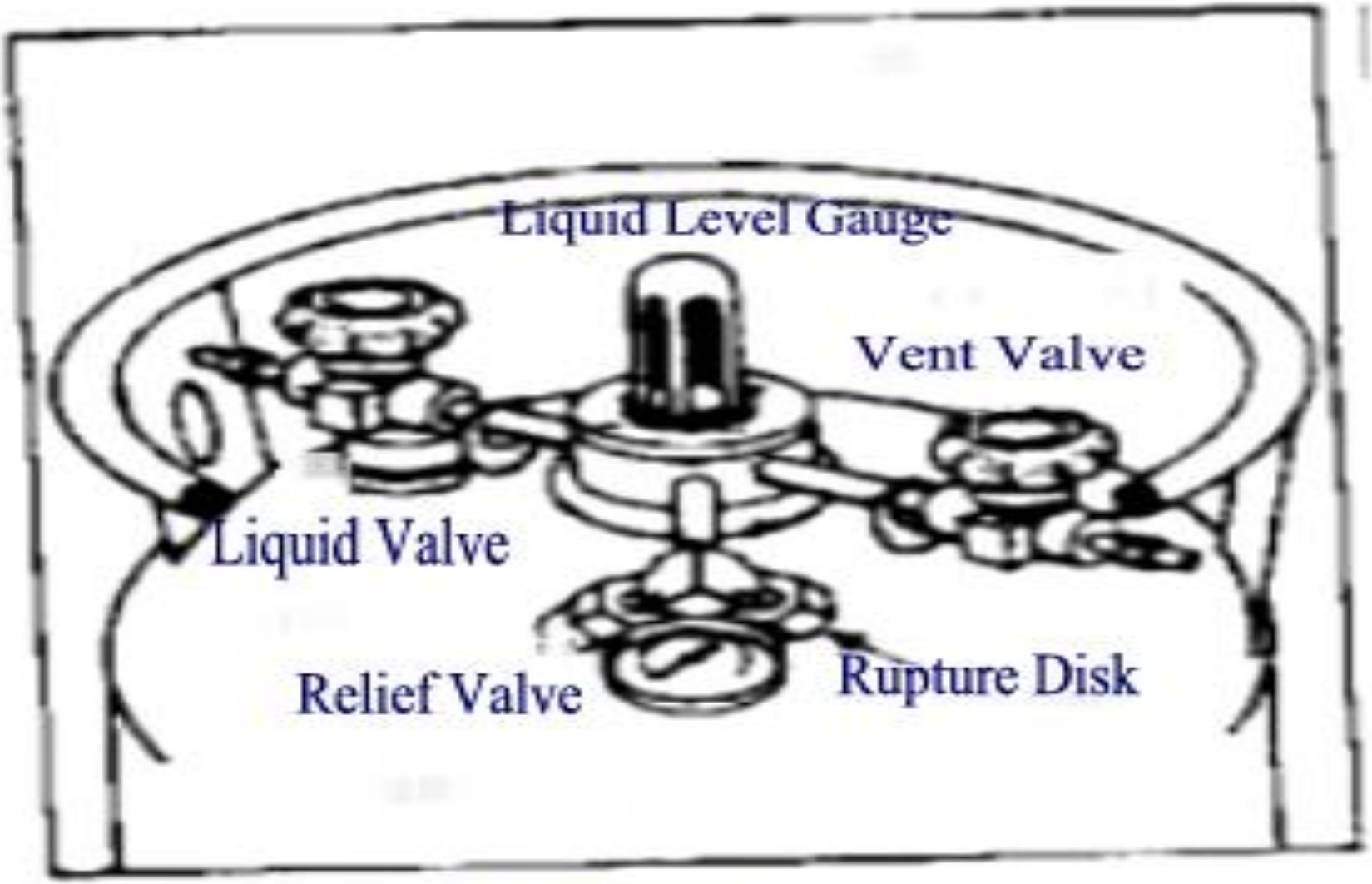
  Liquid is withdrawn through this valve

- Pressure Gauge

  Displays internal pressure of the container

- Contents Gauge

  A float-type liquid level gauge-indicates approximate level of liquid



Low Pressure
Liquid Container
Components

Low Pressure Liquid Container Components

- Vent Valve

  Primarily used in the fill process to vent the vapor space while filling. Can be used to vent unwanted pressure during storage and use

- Pressure Relief Devices (2)

  Protect vessel from over-pressurization

  -Re-seating spring-loaded relief valve releases at 22 psig

  -Burst disk rated to protect the inner vessel

Low Pressure Liquid Container Components

- Outlet Restraints

  These are to prevent the dangerous practice of changing outlet connections at user sites. These restraints may be twist ties, wire, or other.

  Removal of these restraints will void all product warranties!!

  Changing outlet connections is an extremely dangerous practice and can result in serious injury or death if an incompatible product is introduced into a user's system

Warning!!!!

- Never plug, restrict, or remove any relief device.
- Never attempt to cap or seal a venting relief device in any way.
- Ice or frost buildup on a pressure relief valve can be removed with a damp cloth. (Wear proper Personal Protective Equipment (PPE) when removing the frost.)

Moving Liquid Cylinders

- Liquid cylinders range in different weights and sizes. They are heavy and cumbersome, especially when filled with liquid nitrogen.
- They may require for two people to handle in order to do so safely.
- Containers can cause crushing injury to the feet. Wear proper shoes. Tennis shoes and open toed shoes are not proper foot protection!!

Moving Liquid Cylinders

- Never try to roll liquid cylinders by using the Liquid Level Gauge tube.
- Note the proper stance and use of the cylinder's halo ring for moving.

Moving Liquid Cylinders

- Always use the specially designed cylinder cart when moving liquid cylinders.
- If the cart has a height adjustment for different cylinders, be sure it's adjusted to the proper height.

Transport

- Use the specially designed and designated handcart
- Do not roll, either vertically or horizontally
- Push, Don’t Pull
- If the container tips over, let it go

Elevator Transport

- Use freight elevator if possible
- If a passenger elevator is used, it must be locked out to all other users
  - Have one person at the sending floor, and one at the receiving floor
- Do not transport a liquid nitrogen container at any time in an elevator with any personnel in the car unless they have a supplied air respirator

Emergencies

- If there is a large spill or rupture of a container, call 911, warn others in building
- **Evacuate!! There may be oxygen deficiency in the area of the spill!!**
- If there is injury to the body from liquid nitrogen, seek immediate medical assistance

Emergencies

- If liquid is splashed in the eyes, flush with water for at least 15 minutes. Seek immediate medical attention. **Call 911**
- Skin contact may cause frostbite and burns. Soak affected part in tepid water and seek immediate medical attention. **Call 911**
- Skin contact is a medical emergency.

CALL 911

Personal Protective Equipment (PPE) for Cryogenics

- If you transfer cryogenic liquids the possibility of cryogenic liquid coming in contact with the skin is reduced with the use of proper Personal Protective Equipment (PPE).
  - Full Face Shield with safety glasses
  - Heavy, Loose Fitting leather or Cryogenic Gloves
  - Long Sleeve Shirt, or Arm Protection
  - Pants should be cuff-less
  - Do not tuck pants into shoes, boots.
- Contact EH&S at 4-7329 for PPE selection guidance

Liquid Withdrawal

- Caution!!
- Always wear a full face shield, goggles, leather or cryogenic gloves, safety shoes, and aprons when transferring liquid.
- Ensure that the liquid cannot collect in pants cuffs or travel down into shoes. Do not tuck cuffs into pants! Cuff gloves over sleeves.
- Transfer of liquids at pressures higher than 22 psig into open vessels such as small dewars can lead to excessive splashing. This could result in injury from freezing of the body part

Operation

- Caution!!!

  Before use, always confirm that the Compressed Gas Association (CGA) fittings are appropriate for the product identified on the cylinder label.

  If a mismatch appears, do not attempt to use the container.

  If help is needed, ask your supervisor or supplier

Liquid Withdrawal

- Ensure that withdrawal hose is equipped with a phase separator to prevent splashing. Check with supervisor or supplier.
- Never dispense liquid into an unapproved container, such as a Thermos® bottle. It will shatter!

Troubleshooting

- Issue: Gas vents intermittently through safety relief valve
- Possible cause: Probably normal operation. Gas generated due to heat leak into cylinder causes head pressure to build
- Recommended Activity: Ensure inactive containers are stored in well ventilated area. Rotate inventory

Troubleshooting

- Issue: Gas vents continuously through safety valve
- Possible Cause: Possible relief valve failure or excessive heat leak
- Recommended Activity: Remove container or vent the exhaust to a well ventilated area. Relieve product through vent valve. Check to see if safety relief valve is frozen open. Contact supervisor or supplier for assistance

Troubleshooting

- Issue: Gas vents during use through safety relief valve
- Possible Cause: Set point on regulators exceeds safety relief valve setting
- Recommended Activity: Reduce set point on pressure building regulator-Contact supervisor or supplier for assistance

Troubleshooting

- Issue: Pressure in the container is low
- Possible Cause: Leak from container
- Recommended Activity: Use appropriate leak detection fluid to check for leaks in connections. Examine container for signs of frost. If leaks are on container itself, contact supervisor or vendor.

Troubleshooting

- Issue: Pressure in the container is low
- Possible Cause: Pressure building valve is not fully opened
- Recommended Activity: Open valve fully

Troubleshooting

- Issue: Pressure in the container is low
- Possible Cause: Pressure building regulator not set high enough
- Recommended Activity: Adjust to increase pressure-contact supervisor or supplier

Troubleshooting

- Issue: Pressure in the container is low
- Possible Cause: Pressure building valve is open
- Recommended Activity: Close the valve if frost is visible on the pressure building vaporizer near the bottom of the tank-contact supervisor or supplier

Troubleshooting

- Issue: Pressure in the container is too high
- Possible Cause: Leaking or improper setting of pressure building regulator
- Recommended Activity: Reduce regulator setting to achieve desired pressure level-contact supervisor or supplier

Troubleshooting

- Issue: Pressure in the container is too high
- Possible Cause: Vacuum integrity failing
- Recommended Activity: If container walls are covered with frost, contact supervisor or supplier

Troubleshooting

- Issue: Container top covered with frost
- Possible Cause: High product use
- Recommended Activity: Normal operation

Troubleshooting

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

Troubleshooting

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

References and Assistance

- Airgas Safety - 800-827-2338
- Airgas Safetygram-27, Cryogenic Liquid Containers
- MSDS on Liquid Nitrogen - UCDHS MSDS site: http://msds
- EH&S – 916-734-2740

Questions?

Contact Environmental Health and Safety at 916-734-2740 or E-mail at john.danby@ucdmc.ucdavis.edu