

Liquid Nitrogen Safety

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Objectives

- Workers will be able explain two hazards of liquid nitrogen
- Worker will be able select correct PPE for transferring liquid nitrogen
- Workers will be able identify two precautions needed of using liquid nitrogen in cooling concrete.

Clean Air Paradox

- **Quality** of Air
- 78.1% Nitrogen
- 20.9% Oxygen
- 0.9% Argon
- 0.03% Carbon Dioxide



What are Cryogenics

- All cryogenic liquids are gases at room temperature and atmospheric pressure.
- The gases are liquefied at very low temperature and high pressures.
- Cryogenic liquids are materials with boiling points of less than 73 C (100 F).



Properties

- Extremely cold in liquid state
- Small quantities of liquid may expand to large volumes of gas
- Expansion Ratio, (liquid to gas) 1 to 694



Common Cryogenics

- Liquid Nitrogen
- Liquid Helium
- Dry Ice (Carbon Dioxide)



Liquid Nitrogen

- Liquid Nitrogen is heavier than air, inert, colorless, non-corrosive, non-flammable, and extremely cold.
- Boiling Point at 1atm is $-195.8\text{C}/-320.4\text{F}/77\text{K}$
- Under certain conditions, nitrogen can react violently with lithium, neodymium, titanium (above $1472\text{F}/800\text{C}$), and magnesium to form nitrides.



Hazards

- Extreme Cold - Frostbite
- Oxygen Deficiency - Asphyxiation
- Over Pressurization - Physical Injury



Exposure

- Directly touching the liquid with your skin
- Indirectly touching something cooled by the cryogenic liquid like a metal transfer line
- Indirectly by exposing skin or eyes to the cold gas coming out of a pressure relief valve at the end of a transfer line



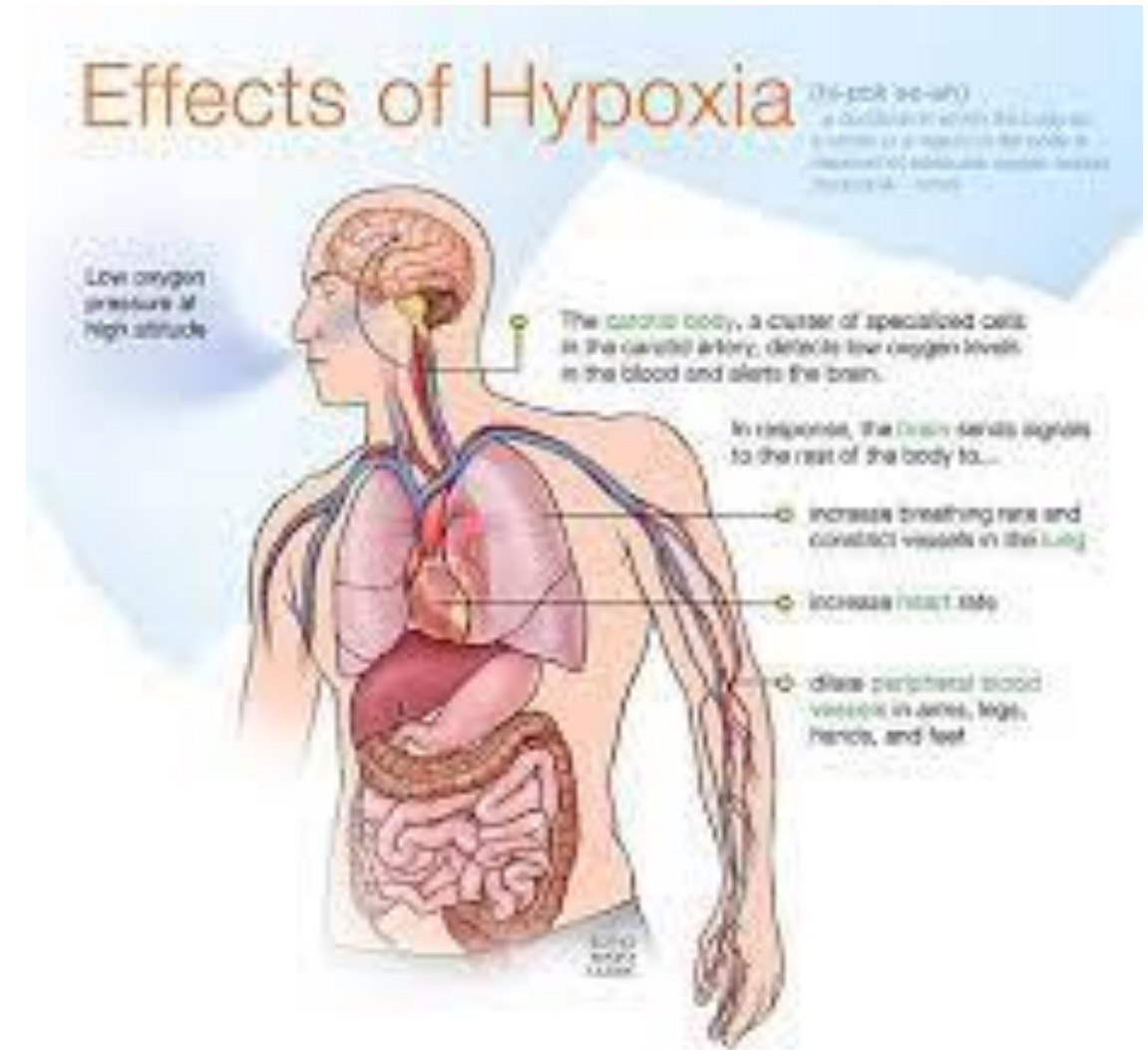
Extreme Cold Hazards

- Cryogenic liquids and cold vapors can cause thermal burn injuries, frostbite.
- Brief exposures may damage tissue.
- Breathing extremely cold air may damage lungs.
- Skin may stick to metal that is cooled by cryogenic liquids and when pulled away the skin may tear.
- Non-metallic materials are also dangerous to touch at cryogenic temperatures.



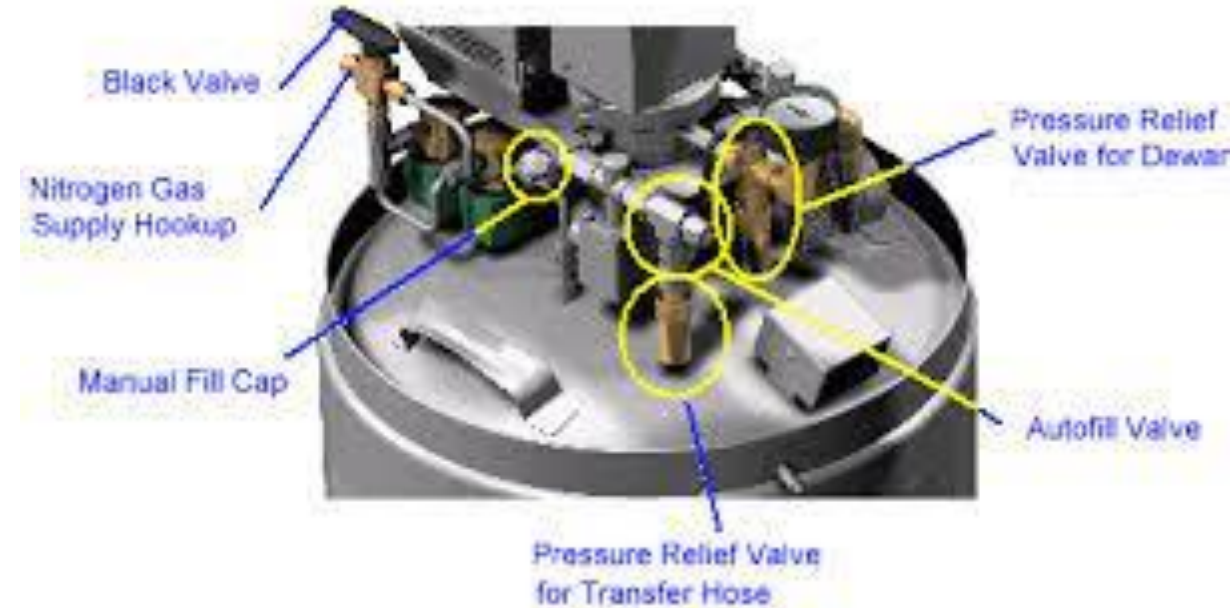
Oxygen Deficiency (Asphyxiation)

- Occurs without any warning
- Due to oxygen displacement
- Cryogenic liquid warms up it becomes a gas, the gas is still very cold.
- Liquid N₂ gas is heavier than air.
- Increased hazards associated with large volumes of cryogenics in small spaces.



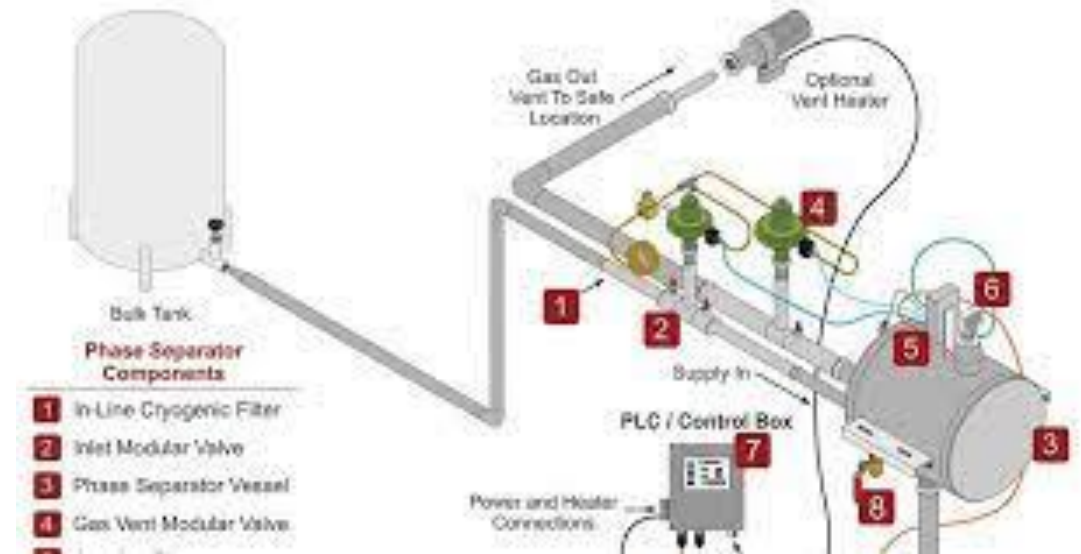
Over Pressurization – Hazard

- Without adequate venting or pressure-relief devices on closed containers containing cryogenics, enormous pressures can build up.
- The pressure may cause an explosion.
- The pressure relief valve must be properly installed and free from obstruction.



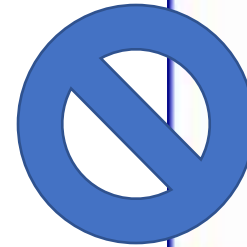
Cryogen Safety Guidelines

- Equipment should be kept clean.
- Perform routine inspections of all safety equipment and cryogenic systems.
- Mixtures of gases or fluids should be strictly controlled to prevent formation of flammable or explosive mixtures.
- Containers and systems containing cryogenics should have pressure relief mechanisms.



Cryogen Safety Guidelines

- Ensure that all pressure relief valves and rupture disk vent paths are directed away from personnel.
- Containers and systems should be capable of withstanding extreme cold without becoming brittle.
- Glass containers should be taped solidly around the outside or encased in plastic mesh.
- Funnels should not be used for pouring liquid nitrogen or any other cryogen.



What hazards?

Knowledge Check

- Two hazards of liquid nitrogen are:
 - Flammable
 - Very Cold Liquid
 - Poisonous at 1 ppm
 - Asphyxiation
 - Cancerous

Knowledge Check

- Two hazards of liquid nitrogen are:
 - Flammable
 - **Very Cold Liquid**
 - Poisonous at 1 ppm
 - **Asphyxiation**
 - Cancerous

2016 Death



- CANTON, Ohio -- After a 32-year-old male worker was found dead in a control-room at Timken Steel's Faircrest Plant on Sunday, the U.S. Department of Labor's Occupational Safety and Health Administration's Cleveland office said that the worker may have been exposed to too much nitrogen.
- "Companies that have nitrogen systems need to make sure that they recognize the hazard of oxygen deficiency that can be created by its ability to displace oxygen," Howard Eberts, OSHA's Area Director in Cleveland.

Pipes need to be labeled!

Citation

Company Name: TimkenSteel Corporation
Inspection Site: 4511 Faircrest St., SW, Canton, OH 44706

Citation 1 Item 2 Type of Violation: **Serious**

29 CFR 1910.1200(h)(3)(i): The employee training did not include the methods and observations used to detect the presence or release of a hazardous chemical in the work area:

On or about March 20, 2016, the employer failed to ensure employees working with nitrogen to power pneumatic tools received training on the hazards, effects and detection of nitrogen.

ABATEMENT DOCUMENTATION REQUIRED FOR THIS ITEM

Date By Which Violation Must be Abated:
Proposed Penalty:

09/19/2016
\$9799.00



Nov 2018

- 3 Dead in cryogenic cooler room.
- Alberta Canada
- Liquid Nitrogen
- Cited - written code of practice for working in the confined space of the cryogenic coolers,
- Establish an emergency response plan for responding to an emergency that may require rescue or evacuation and
- Designate a competent worker to conduct hazard assessments related to working in confined spaces.



2020 Death

- Jan. 28
- Georgia
- **Six people were killed** and at least a dozen others were injured in what was determined to be a nitrogen leak at Foundation Food Group poultry processing plant



OSHA

- Over \$1,000,000 to Contractors and Foundation Foods
- In Contest
- Lockout Procedure for the freezer
- PPE Hazard Assessment
- Hazcom - Labels for Nitrogen Hazard
- Hazcom - Asphyxiation hazard of Nitrogen



Citation General Duty

Among other methods, feasible and acceptable means of abatement include:

a - Ensure oxygen deficiency monitoring and alarm system, with both audible and visual notification, is installed within enclosed areas and use of personal oxygen monitors, where the liquid nitrogen (LN2) process equipment operates.

b - Ensure the process enclosure ventilation system design provides adequate air movement (i.e., air changes per hour) across all portions of the room or area to prevent the accumulation of nitrogen vapors.

c - Ensure the liquid nitrogen process equipment including the Line 4 liquid nitrogen Immersion/Spiral freezer has signage identifying the source isolation valves.

d - Develop and implement operations procedures for both normal startup, shutdown, and emergency shutdown conditions, as well as equipment maintenance procedures for cryogenic systems at the facility including the Line 2 liquid nitrogen Spiral freezer and the Line 4 liquid nitrogen Immersion/Spiral freezer.

e - Ensure respiratory protection is provided for employees needing to enter a space where the quality of the air in that space is uncertain.

f - Ensure the liquid nitrogen receiving/supply vessels are inspected and certified for operation.

g - Ensure the liquid nitrogen offloading/fill connection is located at least 10 ft. away from building exits.

Nitrogen

- When the oxygen concentration in air is sufficiently low, a person can become unconscious without any warning symptoms.
- Fixed oxygen detector
- Handheld oxygen detector





CGA-Liquid Nitrogen Safety

- Wear appropriate personal protective equipment (PPE)



 **WEAR APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT (PPE)**

	[FACE SHIELD		[SAFETY GLASSES OR SAFETY GOGGLES
	[INSULATED GLOVES (TYPICALLY LEATHER)		[CLOTHING THAT COVERS THE SKIN AND DOES NOT HAVE CUFFS OR FOLDS THAT COULD TRAP SPILLED CRYOGENIC LIQUID

CGA-Liquid Nitrogen Safety

- Do not lower your head into a liquid nitrogen vapor cloud
- Only use containers and equipment designed for cryogenic service
- Never trap liquid nitrogen in a container, tubing, or piping

The infographic is divided into two horizontal sections. The top section features a blue checkmark icon on the left, followed by the text 'ONLY USE CONTAINERS & EQUIPMENT DESIGNED FOR CRYOGENIC LIQUIDS'. To the right is an illustration of a white liquid nitrogen dewar. Further right, a bracket groups two bullet points: one with a warning symbol (exclamation mark in a circle) and one with a checkmark symbol. The bottom section features a red 'X' icon on the left, followed by the text 'NEVER TRAP LIQUID NITROGEN IN A CONTAINER, TUBING, OR PIPING'. To the right is an illustration of a shattered glass container. Further right, a bracket groups two bullet points: one with a warning symbol and one with an 'X' symbol.

ONLY USE CONTAINERS & EQUIPMENT DESIGNED FOR CRYOGENIC LIQUIDS

MATERIALS THAT ARE NOT DESIGNED FOR CRYOGENIC SERVICE, SUCH AS GLASS OR PLASTIC, CAN SHATTER WHEN EXPOSED TO LIQUID NITROGEN.

ALWAYS USE APPROPRIATE CONTAINERS AND POUR LIQUID NITROGEN SLOWLY TO MINIMIZE THERMAL SHOCK AND SPLASHING.

NEVER TRAP LIQUID NITROGEN IN A CONTAINER, TUBING, OR PIPING

AS THE LIQUID WARMS AND CONVERTS TO GAS, THE PRESSURE RISES, AND CONTAINERS THAT ARE NOT EQUIPPED WITH ADEQUATE VENTS CAN CATASTROPHICALLY RUPTURE.

NEVER PUT LIQUID NITROGEN IN A CONTAINER NOT DESIGNED FOR CRYOGENIC SERVICE.

CGA-Liquid Nitrogen Safety

- Read and understand safety information prior to using liquid nitrogen
- Use liquid nitrogen in well-ventilated areas



**USE LIQUID NITROGEN
IN WELL-VENTILATED
AREAS**



WHEN LIQUID NITROGEN IS EXPOSED TO WARMER AIR, IT RAPIDLY TURNS INTO GAS AND CAN QUICKLY DISPLACE THE AIR IN THE ROOM, CREATING A RISK OF OXYGEN DEFICIENCY AND ASPHYXIATION.



AIR MONITORING IS RECOMMENDED.

Cool Concrete With Liquid Nitrogen Injection

- Maintain low, uniform temperature specifications including less than 50°F, at any production rate
- Realize accurate and flexible temperature adjustments greater than 50°F
- No adverse impact on slump, air content, set time or density
- Reduce delays and safety risks associated with handling ice, no need to purchase a refrigeration system



Concrete & Temperature

- Test on site using a thermometer
- Pumping adds heat, so test at end of pump
- Use ice or liquid nitrogen in summer
- Use hot water or steam in winter



Knowledge Check

- Which of the following PPE would be worn if dispensing liquid nitrogen?
 - Gloves
 - Face Shield
 - Safety Glasses or Safety Goggles
 - Clothing that covers the skin
 - Steel toes shoes

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Photo courtesy:
Michael Gong



Hazard?



Photo courtesy: Michael Gong

Liquid Nitrogen
-321° Fahrenheit

Photo courtesy: Michael Gong

Recommendations?



Take Aways

- Ask Questions about oxygen alarms
- Can you be sprayed or contact liquid nitrogen?
- Is there safe egress to fresh air?
- Are lines marked for content?

Summary

- Oxygen alarms personal and fixed
- Ventilation
- Signs for isolation valves
- Procedures: startup, shutdown and emergency shutdown,
- Respirator when uncertain air quality
- Nitrogen vessel inspected and certified



Cryogenic Food Freezing