NDSU Cryogen Safety Procedures

SAFE OPERATING PROCEDURES

I. OBJECTIVES

This S.O.P. will provide basic information concerning liquid cryogens and their use at NDSU. The information provided includes the following:

- Identifying liquid nitrogen and helium as the primary liquid cryogens used at the NDSU.
- Explains the pressure hazards associated with contained cryogenic fluids.
- Explains techniques used to control hazards associated with cryogenic fluids.
- Identifies a "dewar" and how to properly use it.
- Identifies the major physical/ health hazards associated with cryogens which include air condensation, cold embrittlemen asphyxiation, and skin/ eye contact.
- Identifies danger signs that indicate hazardous conditions within or around a cryogen containment system.
- Identifies personal protection and first aid procedures for treating cryogenic burns.

II. GENERAL INFORMATION/GENERAL SAFETY

Cryogens have physical properties which are not typical of the materials that are found at room temperature and standard atmospheric pressure.

Critical Point and Critical Temperature

The critical point, not to be mistaken with boiling point, is the highest temperature at which a material changes from a gas to a liquid regardless of pressure. The temperature at which this takes place is called the critical temperature. The cryogenic fluids used at the NDSU, namely nitrogen and helium, have very low critical temperatures, 126.3º K(- 232º F) for nitrogen and 5.2º K (- 450º F) for helium.

Cryogenic Fluid Vaporization
Due to the extremely low critical temperatures, when cryogenic fluids are heated (i. e., exposed to room temperature) they turn into a gas very rapidly. If cryogenic fluids are confined inside a container the pressure from the vaporization of the liquid can be great.

Controlling Pressure Releases
To eliminate high pressure releases of cryogenic vapors, containment systems with special pressure- relief devices are used. They typically consist of pressure relief valves and/ or breakable "Burst Disks" to allow overpressures to release safely. Also some containment systems have values which are held in by atmospheric pressure and will eject forcefully during an accident.

Containment System
The containment system used for cryogenic liquids includes an insulated container where the cryogenic liquid is stored, delivery lines, and a vacuum jacket.

The typical container used to store and handle cryogenic fluids at NDSU is the dewar. The dewar is designed with a vacuum jacket for insulation and pressure relief valves to protect against over- pressurization.

Vacuum Jackets
The vacuum jacket acts as an insulating layer for the cryogenic fluid and sometimes includes a system of coiled pipes between the inner and outer walls. The vapors from the cryogenic fluid circulate through the piping system and cool the inner and outer walls of the containment.

The vacuum jacket protects workers from the extreme cold of the cryogenic liquid and protects the cryogenic fluid from the ambient temperature of the surrounding environment.

Pressure Relief Devices
The pressure relief devices found on the dewar usually consists of spring- loaded valves and burst disks. These types of pressure relief devices should be used on any component of the containment system where cryogenic liquid is enclosed, including all delivery lines and cut- off valves.

Proper use of Dewars
All cryogen containers (dewars) should be operated in accordance with the manufacturer's instructions. Proper personal protective equipment must be worn whenever handling cryogenic liquids. Dewars are designed to protect workers from contacting cryogenic fluids and maintain the cryogen in its liquefied state. However, proper dewar handling practices must be used to ensure worker safety.

Safe dewar handling practices include:

- Never cross contaminate in service dewars with other cryogenic liquids.
- Ensure dewars are properly labeled with the identity of the housed cryogen.
- Keep the dewar upright. Do not bump or drop the dewar from an elevation. This could ruin the insulating properties of the dewar. Dewars that fall onto their side could rupture if the inner vessel cracks and cryogenic material flows into the vacuum space between the inner and outer vessels. The cryogen will contact the warm metal and boil rapidly, greatly increasing the pressure in the dewar.
- When using a hand truck or fork truck for dewar transport, the dewar must be strapped onto a dewar transport pallet. Never use chains to secure the dewar to the transport pallet.
- Never slide or roll a dewar.
- Never lift dewars by their handles or by means of slings wrapped around the shell of the dewar.
- Use cryogen rated personal protective equipment when filling, venting, and transferring dewars and cryogenic fluids.
- Ensure dewars are positioned so that the pressure relief valves and rupture disks vent paths are directed away from personnel, critical equipment, or designated work areas.
- The fill and vent ports of the dewar should be kept closed at all times to minimize the formation of ice which may plug the pressure relief devices.
- The pressure relief devices should be periodically inspected for ice.

III. HEALTH HAZARDS & DANGER SIGNS

Hazards Caused by Air Condensation

There is always a chance that the air surrounding a cryogen containment system can condense especially when transferring liquid nitrogen through uninsulated metal pipes or relieving pressure in liquid helium dewars.

Air condensation can cause hazards to workers and equipment.

These include the following:

- It can create a liquid condensate that falls on materials, particularly organic materials, susceptible to cold embrittlement.
- It can increase the oxygen concentration around a containment system, which can increase the flammability of materials near the system. For example, nitrogen, which has a lower boiling point than oxygen, will evaporate first, leaving an oxygen enriched condensate on the surface.

- Clothing saturated with oxygen from air condensed by cryogenic fluids readily ignites and will burn vigorously. Personnel in this situation should immediately leave the area and avoid all ignition sources.
- Based on air condensation effects, equipment containing cryogenic fluids must be kept clear of combustible materials in order to minimize the fire hazard potential.

Controlling Air Condensation

The frost that accumulates on containment system components is very important in controlling air condensation. It insulates the containment system from the surrounding air, reducing the possibility that the air will condense. Another way of reducing air condensation is by applying an insulating material on system components. This not only reduces air condensation but also protects workers by preventing contact with cold cryogenic containment system surfaces.

Cold Embrittlement

Many materials become very fragile at very low temperatures. At cryogenic temperatures (below 222º K), materials such as rubber, plastic and carbon steel can become so brittle that very little stress can break the material.

To avoid problems with cold embrittlement, materials like stainless steel, copper, brass and most alloys of aluminum should be used in the cryogen containment systems.

Asphyxiation Hazard

Cryogen's will rapidly boil and convert from a liquid to a gas at room temperature. As the gas warms to the temperature of the surrounding air, it expands. In confined or poorly ventilated areas, the expanding gas will displace oxygen and can cause rapid asphyxiation or death. Therefore, you should use caution when using liquid nitrogen and helium indoors. These gases are colorless, odorless, and tasteless.

Skin and Eye Hazards

Never make direct contact with cryogenic liquids, uninsulated cryogenic pipes, or uninsulated cryogenic equipment because contact can cause freeze burns and tissue damage. In addition, a jet of cryogen vapors can freeze the skin or eyes faster than liquid contact, even faster than metal contact.

The eyes contain fluids and are especially sensitive to cryogen exposure. These fluids will freeze upon contact with a cryogen causing permanent eye damage. Exposure which does not damage the skin may cause permanent eye damage.

Danger Signs

Workers who handle cryogenic fluids must be aware of conditions, or danger signs, that may indicate the buildup of excess pressure in cryogenic systems.

These conditions may include:

- Elevated pressures indicated on gauges.
- Unexpected frost formation on containment systems.
- Poor or abnormal venting in the containment system.
- Warning alarms indicating low levels of oxygen in the work area.
- Unusual noise or absence of usual venting noises.

IV. PERSONAL PROTECTION & FIRST AID

Personal Protection

The precautions listed below should be followed to protect the eyes and skin from the hazards associated with cryogens.

- Insulate all containment system pipes.
- Use care when filling portable dewars.
- Always wear protective gloves over jewelry because if exposed to cryogenic fluids, the ring can freeze to the finger.
- Protect your eyes by wearing safety goggles or a face shield whenever working with cryogen fluids.
- Always wear a face shield when working around pressurized cryogenic systems, connecting or disconnecting cryogenic equipment lines, or when venting containment systems.
- Wear insulated gloves whenever working around uninsulated pipes or handling dewars.
- Try to cover all exposed skin by wearing long sleeve shirts, cuffless pants, safety boots, and gloves. Gloves should be loose- fitting so that they can be quickly removed if cryogenic fluids are spilled on them.

First Aid

Any time cryogens come in contact with your skin, you should obtain medical assistance as soon as possible.

Immediately after exposure, the frozen skin appears waxy and yellow and usually is not painful to the worker. As the skin thaws, it painfully swells and blisters. When this occurs, immediate emergency treatment is required. While waiting for medical assistance, follow these first aid procedures:

- Remove the victim from the cryogen hazard.
- Remove any clothing that may interfere with the circulation of blood to the frozen tissues. The clothing must be removed in a slow, careful manner to prevent salvageable skin from being pulled off.
- Do not rub the affect areas of skin. Rubbing may further damage the tissue.

- Immerse the affected area in a warm water bath (approx. 105º F). Do not apply dry heat, such as electric heaters, because it may superimpose a thermal burn, further damaging injured tissue.
- If the worker has experienced a massive exposure such that overall body temperature is reduced, the worker should be wrapped in blankets until paramedics arrive. In cases of extreme exposure, the worker should be totally immersed in warm water. Treatment for shock may be necessary.
- The rewarming, or thawing, of affected area(s) should be done gradually. It may take up to 60 minutes to thaw the affected area(s) and bring back the natural colors of the skin.
- If the frozen tissue thaws before medical help arrives, cover the area with dry sterile dressings and large bulky protective clothing. Do not apply ointments.
- Do not allow the exposed worker to drink alcohol or smoke. Alcohol and nicotine decrease blood flow to the frozen tissues. You may give the affected worker warm drinks and food.
- Try to make the worker feel as comfortable as possible.

Minor burns must be reported to the NDSU Safety Office and your supervisor on the Employee Incident report form. Obtain medical attention if appropriate.