NORTHERN ARIZONA UNIVERSITY

**Liquefied Gases and Cryogenic Liquids**

Cryogenic liquids are materials with boiling points of less than -73 °C (-100 °F). Liquid nitrogen, helium, and argon, and slush mixtures of dry ice with isopropanol are the materials most commonly used in cold traps to condense volatile vapors from a system. In addition, oxygen, hydrogen, and helium are often used in the liquid state. The primary hazards of cryogenic liquids are fire or explosion, pressure buildup (either slowly or due to rapid conversion of the liquid to the gaseous state), embrittlement of structural materials, frostbite, and asphyxiation. The extreme cold of cryogenic liquids requires special care in their use. The vapor that boils off from a liquid can cause the same problems as the liquid itself.

1. The fire or explosion hazard is obvious when gases such as oxygen, hydrogen, methane, and acetylene are used. Air enriched with oxygen can greatly increase the flammability of ordinary combustible materials and may even cause some noncombustible materials to burn readily. Oxygen-saturated wood and asphalt have been known to literally explode when subjected to shock. Because oxygen has a higher boiling point (-183 °C) than nitrogen (-195 °C), helium (-269 °C), or hydrogen (-252.7 °C), it can be condensed out of the atmosphere during the use of these lower-boiling-point cryogenic liquids. With the use of liquid hydrogen particularly, conditions may develop for an explosion. It is advisable to furnish all cylinders and equipment containing flammable or toxic liquefied gases (not vendor-owned) with a spring-loaded pressure-relief device (not a rupture disk) because of the magnitude of the potential risk that can result from activation of a non-resetting relief device. Commercial cylinders of liquefied gases are normally supplied only with a fusible-plug type of relief device, as permitted by DOT regulations. Pressurized containers that contain cryogenic material should be protected with multiple pressure-relief devices.Cryogenic liquids must be stored, shipped, and handled in containers that are designed for the pressures and temperatures to which they may be subjected. Materials that are pliable under normal conditions can become brittle at low temperatures. Dewar flasks, which are used for relatively small amounts of material, should have a dust cap over the outlet to prevent atmospheric moisture from condensing and plugging the neck of the tube. Special cylinders insulated and vacuum-jacketed with pressure-relief valves and rupture devices to protect the cylinder from pressure buildup are available in capacities of 100 to 200 liters (L).

2. A special risk to personnel is skin or eye contact with the cryogenic liquid. Because these liquids are prone to splash in use owing to the large volume expansion ratio when the liquid warms up, eye protection, preferably a face shield, should be worn when handling liquefied gases and other cryogenic fluids. The transfer of liquefied gases from one container to another should not be

attempted for the first time without the direct supervision and instruction of someone experienced in this operation. Transfers should be done very slowly to minimize boiling and splashing.

3. Unprotected parts of the body should not be in contact with uninsulated vessels or pipes that contain cryogenic liquids because extremely cold material may bond firmly to the skin and tear flesh if separation or withdrawal is attempted. Even very brief skin contact with a cryogenic liquid can cause tissue damage similar to that of frostbite or thermal burns, and prolonged contact may result in blood clots that have potentially very serious consequences. Gloves must be impervious to the fluid being handled and loose enough to be tossed off easily. A potholder may be a desirable alternative. Objects that are in contact with cryogenic liquids should also be handled with tongs or potholders. The work area should be well ventilated. Virtually all liquid gases present the threat of poisoning, explosion, or, at a minimum, asphyxiation in a confined space. Major harmful consequences of the use of cryogenic inert gases, including asphyxiation, are due to boiling off of the liquid and pressure buildup, which can lead to violent rupture of the container or piping. In general, liquid hydrogen should not be transferred in an air atmosphere because oxygen from the air can condense in the liquid hydrogen, presenting a possible explosion risk. All precautions should be taken to keep liquid oxygen from organic materials; spills on oxidizable surfaces can be hazardous. Though nitrogen is inert, its liquefied form can be hazardous because of its cryogenic properties and because displacement of air oxygen in the vicinity can lead to asphyxiation followed by death with little warning. Rooms that contain appreciable quantities of liquid nitrogen (N2) should be fitted with oxygen meters and alarms. Liquid nitrogen should not be stored in a closed room because the oxygen content of the room can drop to unsafe levels.

4. Cylinders and other pressure vessels used for the storage and handling of liquefied gases should not be filled to more than 80% of capacity, to protect against possible thermal expansion of the contents and bursting of the vessel by hydrostatic pressure. If the possibility exists that the temperature of the cylinder may increase to above 30°C, a lower percentage (e.g., 60%) of capacity should be the limit.