3.10. Cryogenic Liquids – Procedures for Safe Handling and Storage

Cryogenic liquids are liquefied gases having boiling points of less than -73.3°C (-100°F). The primary hazards of cryogenic liquids include both physical hazards such as fire, explosion, and pressure buildup and health hazards such as severe frostbite and asphyxiation. Potential fire or explosion hazards exist because cryogenic liquids are capable, under the right conditions, of condensing oxygen from the atmosphere. This oxygen-rich environment in combination with flammable/combustible materials and an ignition source are particularly hazardous. Pressure is also a hazard because of the large volume expansion ratio from liquid to gas that a cryogen exhibits as it warms and the liquid evaporates. This expansion ratio also makes cryogenic liquids more prone to splash and therefore skin and eye contact is more likely to occur. Contact with living tissue can cause frostbite or thermal burns, and prolonged contact can cause blood clots that have very serious consequences. All laboratory personnel must follow prudent safety practices when handling and storing cryogenic liquids.

3.10.1. Properties of Common Cryogenic Liquids

<table>
<thead>
<tr>
<th>Gas</th>
<th>Boiling Point °F (°C)</th>
<th>Liquid to Gas Volume Expansion Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helium</td>
<td>-452 (-268.9)</td>
<td>1-757</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>-423 (-252.7)</td>
<td>1-851</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>-321 (-195.8)</td>
<td>1-696</td>
</tr>
<tr>
<td>Fluorine</td>
<td>-307 (-187.0)</td>
<td>1-888</td>
</tr>
<tr>
<td>Argon</td>
<td>-303 (-185.7)</td>
<td>1-847</td>
</tr>
<tr>
<td>Oxygen</td>
<td>-297 (-183.0)</td>
<td>1-860</td>
</tr>
<tr>
<td>Methane</td>
<td>-256 (-161.4)</td>
<td>1-578</td>
</tr>
</tbody>
</table>

*Note: Absolute zero = - 459.67 °F (- 273.15 °C)*

3.10.2. Handling

- Appropriate personal protective equipment must be worn when handling cryogenic liquids. This includes special cryogen gloves, safety goggles, full face shield, impervious apron or coat, long pants, and full coverage shoes. Gloves must be impervious and sufficiently large to be readily removed should a cryogen be spilled. Watches, rings, and other jewelry should NOT be worn.
- Unprotected body parts must not come in contact with vessels or pipes that contain cryogenic liquids because extremely cold material may bond firmly to the skin and tear flesh if separation is attempted.
- Objects that are in contact with cryogenic liquid must be handled with tongs or proper gloves.
- All precautions should be taken to keep liquid oxygen from organic materials; spills on oxidizable surfaces can be hazardous.
- All equipment should be kept clean, especially when working with liquid or gaseous oxygen.
- Work areas must be well ventilated.
- Transfers or pouring of cryogenic liquid must be done very slowly to minimize boiling and splashing.
- Cryogenic liquids and dry ice used as refrigerant baths must be open to the atmosphere. They must never be in a closed system where they may develop uncontrolled or dangerously high pressure.
- Liquid hydrogen must not be transferred in an air atmosphere because oxygen from the air can condense in the liquid hydrogen presenting a possible explosion risk.
3.10.3. Storage

- Cryogenic liquids must be handled and stored in containers that are designed for the pressure and temperature to which they may be subjected. The most common container for cryogenic liquids is a double-walled, evacuated container known as a Dewar flask.
- Containers and systems containing cryogenic liquids must have pressure-relief mechanisms.
- Coolers and Styrofoam boxes may be used for storage of small amounts of solid carbon dioxide (dry ice) only. Do not use coolers and Styrofoam boxes as the primary container for the transportation and storage of liquid cryogens.
- Cylinders and other pressure vessels such as Dewar flasks used for the storage of cryogenic liquids must not be filled 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 (86°F), a lower percentage (e.g., 60% capacity) should be the limit.
- Dewar flasks should be shielded with tape or wire mesh to minimize flying glass and fragments should an implosion occur.
- Dewar flasks must be labeled with the full cryogenic liquid name and should be labeled with hazard warning information.
- Work and storage areas must be well ventilated.
- Evaporation of the liquid cryogens will displace oxygen in the room and may present an asphyxiation hazard. Air contains about 21% oxygen and breathing air with less than 19.5% is considered a dangerous oxygen deficient atmosphere. Concentrations of 18% can cause dizziness and result in unconsciousness and death.
- Note: The cloud that appears when liquid nitrogen is exposed to air is condensed moisture in the atmosphere. Gaseous nitrogen is invisible.
- Do not store cryogenic Dewar's in walk-in refrigerators. Typical walk-in refrigerators only receive fresh air when the door is opened. Evaporating liquid cryogens could displace enough air to create an oxygen deficient atmosphere.