Cryogen Safety Narrative

Welcome to MIT's cryogen safety training program for laboratory personnel. The training will take approximately 25 minutes to complete. It will review the safe practices that must be followed when working with cryogenic liquids in laboratories. If you have a question as you progress through the material, you can email the EHS Office directly from the program by clicking on the link in the upper right hand corner. Please note that there is a table of contents on the left hand side of the screen. You will be able to track your progress through the program here. The table's navigation feature will also allow you to jump directly to specific content. However, if this is your first exposure to this course, we suggest you allow the program to direct your progress. At the end of this program is a short quiz. When successfully completed, your participation will be automatically documented. OK, let's get started.

The specific learning objectives for this training are summarized in this slide. Please review them and then click on the "next slide" button in the lower right hand corner to continue.
At the end of this training you will be able to:

- List three primary hazards associated with cryogens and the methods for controlling them
- Select an appropriate laboratory cryogen container and describe its safety features
- Select appropriate personal protective equipment (PPE) for a task involving cryogens
- Identify/locate the correct procedure for:
  - safely filling a transfer Dewar from a large 160 or 240 liter container
  - transporting cryogens
- Describe the immediate first aid response measures to cryogen splash
- Describe the appropriate response to a spill of a cryogen

Section 1: Cryogenic liquids Characteristics and Hazards

What are cryogenic liquids and how are they used?
Cryogenic liquids (cryogens) are compressed liquefied gases that are kept in their liquid state at very low temperatures in special insulated containers. All cryogenic liquids are gases at normal temperatures and pressures and have boiling points below -150^{o}C (-238^{o}F). Cryogenic liquids are widely used in the laboratory for storing biological samples, chilling chemical traps and creating inert atmospheres. They are also used to cool specialized laboratory equipment including the superconducting electromagnets in NMR spectrometers.

Hazards associated with all cryogenic liquids
There are three primary hazards associated with the cryogenic liquids handled in laboratories – the extreme cold hazard, the asphyxiation hazard and the pressurization hazard. We will focus our attention on these hazards first and later in the program will address a few special hazards associated with specific cryogens.

Extreme cold hazard
The extreme cold hazard. Cryogenic liquids and their associated cold vapors can freeze tissue causing a cryogenic burn or frostbite. Wet skin is particularly vulnerable to freezing. Delicate tissues such as the eyes can be permanently damaged even after very brief exposures that would not affect skin on the face or hands. There is often no initial pain when tissue freezes, but there is intense pain when frozen tissue thaws. Unprotected skin may also adhere to metal, and even non-metallic materials, cooled by cryogenic liquids. The skin can tear when pulled away. And finally, at cryogenic temperatures, many materials, such as rubber and plastic can become so brittle that they shatter releasing cryogenic liquid. Press the play button for a demonstration or the next slide button to continue.

To protect against the extreme cold hazard, personal protective equipment is always worn to prevent direct skin and eye contact. Special insulated tools are used when working with cryogenic liquids and only materials approved for use with cryogens should ever be placed in direct contact with it.

Asphyxiation hazard
The asphyxiation hazard. As cryogenic liquid transitions from a liquid to a gas it expands dramatically. For example, one liter of liquid nitrogen expands to approximately 700 liters of nitrogen gas when warmed to room temperature. As this expansion occurs, air and particularly oxygen is displaced, reducing the oxygen available to support life. When there is insufficient oxygen in the air, asphyxiation and death can occur. Oxygen-deficient atmospheres have no warning properties. Unconsciousness can be immediate and death can occur within minutes when inhaling pure inert gases or air with less than 5% oxygen. Oxygen deficiency is a particularly serious hazard when cryogenic liquids are handled or spilled in enclosed or confined spaces. The graph on this slide describes the effects on the human body of oxygen concentrations below and above 21%, the natural level. Click on the image to enlarge it or the next slide button to continue.

To prevent an oxygen deficient atmosphere from developing, cryogenic liquids must be handled in well ventilated spaces – avoid cold rooms, closets and other unvented small spaces. Monitoring devices may be used to detect oxygen deficiencies.

Pressurization hazard
The pressurization hazard. Cryogenic liquids allowed to warm within a container, hose or other confined space can quickly generate enormous pressures and cause an explosion. For example, liquid nitrogen would pressurize a container to 10,230 pounds per square inch (psi) if allowed to warm to room temperature. This pressure would likely blow apart any container or system confining it.

The table on this slide summarizes some of the physical characteristics of common cryogenic liquids that relate to their pressurization hazard. I would like to highlight the liquid-to-gas expansion ratio which describes the change in volume as the gas transitions from liquid to gas at room temperature. The resulting pressure that would be generated inside a container from trapped liquid under these conditions is also listed.

	He	N_2	O_2	CO_2
Boiling point °F (1 @ atm)	-452	-321	-297	-108
Change in volume as liquid expands to gas at room temperature (liquid-to-gas expansion ratio)	780	710	875	790
Pressure generated from trapped liquid allowed to warm to room temperature	10,950 psig	10,230 psig	Not Specified	Not Specified

Note 1: Although CO_2, which has a slightly higher boiling point, is technically not cryogenic liquid but has similar properties and is often included in this category. *(Note: Source Argonne National Laboratory)*

To prevent this buildup of pressure, cryogenic liquids must only be stored in approved vessels or containers fitted with a loose fitting lid or a pressure relief valve. All sections of piping and containers, which will hold cryogens and may be isolated with valves, must have a mechanism for pressure relief.

The system must be capable of withstanding 150% of the maximum relief pressure. Pressure relief vents must never be modified or tampered with and must be checked periodically for leakage, icing and plugging. Ice or frost buildup on a pressure relief valve can be removed by tapping the relief valve gently.

Specialized engineering expertise is required when designing and building a system in which cryogens will be used. The EHS Office can assist in locating it.

Special hazards associated with specific cryogens
Two cryogenic liquids handled on campus, liquid oxygen and helium, have additional hazards that researchers must be aware of. If you handle one of these cryogens, please review this information by clicking on the appropriate button on this menu. After reviewing the hazards of the cryogens that you handle, or if you do not handle these cryogens, select the next slide button to continue.

[Menu] Additional hazards associated with liquid oxygen Additional hazards associated with liquid helium

Additional hazards associated with liquid oxygen
Liquid oxygen is an extremely strong oxidizer and may initiate combustion or explosion in flammable, organic, and combustible materials. Clothing saturated (even splashed) with oxygen is readily ignitable and will burn vigorously so it must be removed immediately and aired for several hours. It is also extremely important that equipment and systems that will contact liquid oxygen be cleaned of hydrocarbons – such as oil and other organic solvents - before use and kept from becoming contaminated.

Releases of liquid oxygen can also result in the oxygen enrichment of the surrounding atmosphere. An oxygen enriched atmosphere is considered to be one containing more than 23.5% oxygen. Inhaling oxygen enriched atmospheres can result in adverse health impacts. These atmospheres can also make some materials more susceptible to ignition and burn with greater intensity. Even some materials that are usually considered non-combustible, such as carbon and stainless steels, cast iron, aluminum, zinc and Teflon, may burn in the presence of liquid oxygen.

For additional information on liquid oxygen's hazards and safe handling practices, click on the resource link below.

Additional hazards associated with liquid helium
Liquid helium is so cold that metal surfaces in contact with it, such as transfer hoses, will condense air. This condensate, a mixture of liquid nitrogen and oxygen, will drip and form pools. Nitrogen evaporates from the condensed air more rapidly than oxygen. This leaves behind a mixture which increasingly becomes more oxygen-enriched. This oxygen-enriched fluid now presents all of the same hazards as liquid oxygen. An explosive situation may result if oxygen-rich liquid condensate comes into contact with materials which are not compatible with oxygen – such as oil and other organic solvents. Surfaces where liquid oxygen condensate may form must be thoroughly cleaned and degreased with a non-flammable or hydrocarbon cleaner. For additional information on the hazards associated with liquid oxygen, please review that section before proceeding.

For additional information on liquid helium's hazards and safe handling practices, click on the resource link below.

We will now review in more detail the features of the containers and equipment appropriate for direct contact with cryogenic liquids.

Section 2: Containers and equipment appropriate for direct contact with cryogenic liquids

Containers - general
Only containers and equipment specifically designed for cryogenic liquid use should ever be placed in direct contact with them. A wide variety of different sized containers are available for the storage and transport of cryogens. These include large liquid containers, which may hold up to 240 liters, to small containers holding half a liter. There are also specialty containers available for shipping and storing biological samples. We will now review the features of the more common containers found on campus.

Containers – large liquid containers
Most cryogenic liquids arrive on campus in large liquid containers. These containers are double-walled vessels with a vacuum between the walls to reduce heat transfer into the liquid. They are very heavy. A typical 240 liter container weights 375 lbs. when empty and 775 lbs. when full. The larger containers have five wheels that make them more stable than the smaller containers with four wheels.

There are two types of liquid containers - low pressure and high pressure. Low pressure containers dispense liquid cryogen while high pressure containers dispense the cryogen as a gas. The typical valve configuration of these containers is illustrated here. Please note that both type containers have liquid and vent valves as well as a relief valve and a rupture disk. However the high pressure container has two additional valves – one for dispensing gas and one for building pressure in the container. We will review the use of these valves and the exact procedure for dispensing cryogens from these containers in a moment.

It's important to note the critical role played by the pressure relief valve and rupture disk. Even though these containers are well insulated, heat will continuously leak into the liquid cryogen causing some vaporization to occur. Vaporized product, if not used, will collect in the vapor space above the liquid building pressure in the container. The container will periodically vent this excess pressure through the pressure relief valve. Vaporization rates will vary and may be as low as 0.4% or as high as 3% of the container's volume per day. This is a normal and safe function of the container. If the excess pressure in the container were not released by the pressure relief valve (or other container valve) it would continue building until the container ruptured. To prevent this catastrophic event a rupture disk is incorporated into the system. To make sure that the pressure relief and rupture valves function as designed, do not plug, cap or place anything over them, do not tamper with them and inspect them periodically for ice or frost buildup. Ice or frost buildup on a pressure relief valve can be removed by tapping the relief valve gently. Also, it's important to point the pressure relief valve and rupture disk away from all personnel and pedestrian paths.

A cautionary note on making connections to containers – the fittings must match. One must never use an adaptor or attempt to change a fitting on a container. You will see outlet restraints (twist ties or wire) preventing the changing out of a connection and you must never remove or tamper with them.

One final comment regarding liquid container configuration. You may occasionally see a container with two pressure relief valves. It has been set up this way by the vendor so that the container can be used as either a low pressure liquid dispensing container or a high pressure gas dispensing container. The vendor has set it up properly for your application. Please do not make any changes to this valve.

Containers - Dewars
Liquid cryogens are often stored in laboratories in small quantities in flasks called "Dewars". Dewar flasks are also double-walled containers with a high vacuum between the walls but unlike the liquid containers previously described most Dewars are open, non-pressurized vessels. These flasks come in a variety of sizes and shapes holding from a half a liter to fifty liters. The larger of these Dewars can be fitted with liquid withdrawal devices so that the contents can be dispensed to smaller containers. Non-pressurized Dewar flasks must be kept covered with the loose fitting cap supplied with the container – never replace it. This could result in pressure building in the container. A proper cap also prevents air and moisture from entering. When you put on the cap push it all the way on and then pull up so it is loose. Check to see that the boil-off gases are venting through the indentations inside the lid.

Containers – inappropriate containers –
It should be noted that consumer products such as Thermos bottles are not approved for cryogenic applications. Although the container itself may hold cryogenic liquid in an adequate manner, the lid, even when loosely applied, does not allow for proper venting of boil-off gases. Explosions have resulted from the use of these containers.

Other examples of inappropriate containers for cryogens include ice buckets and Nalgene beakers. An open top Dewar, as illustrated here, is an appropriate substitute.

Equipment appropriate for direct contact
Many common materials such as carbon steel, plastics and rubber become brittle and can crack if exposed to the extremely low temperatures of cryogenic liquids. Many materials also shrink at cryogenic temperatures, potentially causing leaks at hose connections. Make sure that all materials that will come in contact with cryogens are approved for or designed for that purpose.

This completes our discussion of the features of the containers and equipment appropriate for use with cryogenic liquids. We will now focus our attention on the requirements for areas in which large quantities of cryogens are dispensed or handled.

Section 3: Container storage and ventilation guidance
Cryogenic liquids vaporize naturally over time and are released into the environment. In addition, spills may occur in areas where they are used or dispensed, resulting in immediate and complete volatilization of the spilled material. Large cryogen releases can displace oxygen to a level that makes the air unsafe to breathe. For this reason cryogenic liquids must only be stored, dispensed and handled in very well ventilated areas. The ventilation system should be able to maintain a safe airborne concentration of the cryogen and oxygen at all times during normal use and after your largest anticipated spill. In some locations where larger volumes of cryogens are dispensed, stored or handled, the airborne concentration of oxygen is monitored continuously and an alarm sounds if the ambient oxygen content falls below 19.5%. Become familiar with your monitor's alarm and if it activates, or if at any time you feel that an oxygen deficient atmosphere exists, immediately exit the area and notify the EHS Office. The greatest risk for the development of an oxygen deficient atmosphere occurs during a cryogen spill in a confined or poorly ventilated space. The EHS Office can assist you in determining if the ventilation system in your lab or cryogen storage area is sufficient.

It is also imperative that locations used for dispensing cryogens be orderly and away from pedestrian traffic if possible. Four feet of clearance in front of containers or Dewars is recommended. Considerable splashing can occur when dispensing a cryogen to a warm container. To keep floor tile from cracking from exposure to a cryogen in the dispensing area, consider protecting it with cardboard or similar material.

This completes our discussion of container storage and ventilation guidance for areas in which cryogens are dispensed or handled. We will now review the selection and use of personal protective equipment.

Section 4: Personal protective equipment use and selection

Personal protective equipment is worn to prevent skin and eye exposure to: (1) liquid splashes of cryogens; (2) gas releases of cryogens, and (3) the surfaces and objects chilled by these liquids The PPE worn is dependent on the task performed and the potential for exposure.

Before donning PPE and working with cryogens you should first remove watches and metal jewelry from the wrists and hands. The metal can freeze to the skin if exposed to cryogenic liquids or gases and can wear holes in cryogenic gloves. At all times when working with cryogens you should be wearing safety glasses and a laboratory coat or long sleeve shirt. Closed toed shoes and long pants without cuffs are also important because any "catch points" or openings in clothing or footwear could trap liquid cryogen against your skin. Many skin injuries have occurred when the cryogen becomes trapped against the body by personal protective equipment, clothing or shoes.

To this basic ensemble one adds cryogenic gloves whenever there is potential hand exposure to liquid splashes, pressurized gas releases or contact with cold surfaces such as transfer hoses. Cryogenic gloves should extend over the sleeve of your lab coat or shirt and must be loose fitting. This allows the glove to be removed with a flick of the wrist if the cryogen enters the glove. Face shields are added when working with cryogens under pressure or when there is potential face exposure to liquid splashes or pressurized gas releases. This condition exists whenever filling a Dewar from a pressurized container or when pouring liquid cryogens from a height above waist level. Please note that pouring above waist level should be avoided whenever possible. Finally cryogenic aprons are occasionally worn when the potential for a splash to the body is significant. If you spill or splash a cryogen on your gloves, other personal protective equipment or clothing, remove them and allow them to dry and warm up. You may not feel the cold immediately, but you will a few seconds later.

This table summarizes the general rules for selecting clothing and personal protective equipment when working with cryogens. Please review it. If you would like more information on selecting personal protective equipment, consult your lab specific PPE assessment which is available from your EHS representative. When you are ready to continue, select the next slide button.

Clothing and PPE Recommendations	**When worn**
Laboratory coat or long sleeve shirt Safety glasses with side shields Closed toed shoes Long pants (no cuffs)	At all times when working with cryogens
Cryogenic gloves Note: Thermally insulated hand tools may be an alternative to gloves in some instances.	When there is potential hand exposure to liquid splashes, pressurized gas releases or contact with cold surfaces
Face shield	When working with cryogens under pressure or when there is potential face exposure to liquid splashes or pressurized gas releases
Cryogenic apron	When the potential for a splash to the body is significant

A variety of common tasks conducted with cryogens are listed on this slide. Please take a moment to decide what type of personal protective equipment would be appropriate for each task. And then roll your mouse over the task to view the recommended personal protective equipment. You can review the table presented in the previous slide by rolling your mouse over its icon. When you are ready to continue select the next slide button.

Task	Recommended PPE
Dispensing cryogen from a pressurized 240 liter container to an open Dewar	Cryogenic gloves Face shield
Pouring small non-pressurized volume (1 liter) of cryogen between open Dewars	Cryogenic gloves
Removing biological samples or other materials from a liquid nitrogen freezer	Cryogenic gloves
Cooling biological samples in open Dewar	Cryogenic gloves Note: Thermally insulated hand tools may be an alternative to gloves in some instances.
Filling 160 liter liquid container from bulk cryogen storage tank	Cryogenic gloves Face shield Cryogenic apron
Transporting 160 liter liquid container through corridor	None

This completes our discussion of the selection and use of personal protective equipment. We will now demonstrate how the safety concepts we have just reviewed are integrated into some specific procedures performed with cryogens. We will start with a task that almost everyone performs - dispensing liquids from a low pressure container. Before we get started we should note that a web course, no matter how good, is not a substitute for hands-on training from an experienced lab mate or coworker. We encourage you to seek hands-on training before doing any new task with cryogens. Ok, let's dispense some liquid cryogen.

Section 5: Task specific safe operating procedures

Dispensing liquids from a low pressure container

Before dispensing liquid cryogen from a large container it's essential that you understand the placement and function of a container's dispensing components. Low pressure containers only dispense liquids and are typically configured as illustrated in this image. They have:

- a liquid valve for dispensing liquid cryogen (it will often be blue in color),
- a vent valve for relieving excess tank pressure (it will often be silver in color),
- a pressure gauge for determining tank pressure (often 22 pounds per square inch), and
- a liquid level gauge for estimating the quantity of liquid in the cylinder.

Please note - if you see any other valve on your liquid dispensing container, such as this gas building valve, it is not used in a laboratory setting for dispensing liquids and should not be handled.

The following procedure should be used when dispensing liquid cryogen from a low pressure container to a Dewar…

- Don a face shield and cryogenic gloves. You should also be wearing safety glasses long pants without cuffs, closed-toed shoes, and a laboratory coat.

- Next attach a transfer line to the liquid valve, if one is not already present, making sure the fittings match. Please note that the valve will be labeled. The transfer line should have a phase separator attached to reduce turbulence and the release of gas while filling.
- Check the pressure in the cylinder. It should read approximately 22 pounds per square inch. Position the Dewar on the floor at the base of the cylinder, or on some other support below waist level and insert the transfer line into the Dewar. The end of the transfer line should extend to the bottom, or just off the bottom, of the Dewar. Keep bystanders at least four feet away while filling in case of splashing.
- Open the liquid valve one half to three quarters of a turn to begin cooling down the transfer hose and adding the cryogen to the Dewar. The warm hose and Dewar will vaporize the cryogen as it cools and this could create splashing particularly if it is added too quickly. The pressure in the container will drive the liquid out through the valve.
- Once the hose and Dewar have cooled, open the liquid valve to obtain the desired rate of flow. However, if you fully open the valve, be sure to close it a quarter turn. A fully opened valve may freeze in that position causing a spill. A good flow rate is typically evident by a moderate vapor trail coming from the mouth of the Dewar. Listen for the change in sound as the Dewar fills – a higher pitch indicates the Dewar is getting full.
- When full, close the liquid valve. Remove the transfer line but be careful not to drop it on the floor or allow the phase separator to hit a solid object which will cause it to break. Keep your foot and leg away from any cryogen that continues to spill out of the transfer hose. Finally, place the top on the Dewar, pushing it all the way on and then pulling it up so that it is loose.

Menu

Now we will look at some tasks that are routinely conducted in our laboratories, but not by everyone. On this menu please select and review each task that you perform as part of your job. After reviewing all of the tasks that you conduct, click on the continue button to jump to the next section of this training program. Please note that some tasks, such as filling large liquid containers from bulk tanks and adding helium to the reservoirs cooling superconducting magnets, are very specialized and the individuals performing them are given additional training not covered here.

[Menu]
Dispensing cryogens
- Dispensing gas from high pressure containers
- Dispensing from a Dewar to smaller containers

Transporting large liquid containers and Dewars
- Liquid containers
- Dewars
- Elevators: Additional Safety Precautions

Shipping with cryogens
Disposing cryogens

Dispensing gas from a high pressure container

Before dispensing gas from a high pressure container it's essential that you understand the placement and function of a container's dispensing components. High pressure cylinders only dispense gas and are typically configured as illustrated in this image. They have:

- a gas use valve for dispensing gas (it will often be green in color),
- a pressure building valve for creating sufficient pressure in the cylinder for sustained gas delivery (it will often be green in color),
- a vent valve for relieving excess tank pressure, (it will often be silver in color),

- a pressure gage for determining tank pressure (typically 230 pounds per square inch for nitrogen) but will vary with gas delivered, and
- a liquid level gauge for estimating the quantity of liquid in the cylinder.

Please note - if you see any other valve on your gas dispensing container, such as this liquid valve, it is not used in a laboratory setting for dispensing gases and should not be handled.

The following procedure should be used when setting up a high pressure liquid container to dispense gas:

- Don cryogenic gloves. You should also be wearing safety glasses long pants without cuffs, closed-toed shoes, and a laboratory coat.
- Check the pressure in the cylinder. It should be approximately 230 pounds per square inch, but this will vary with the gas dispensed.
- Next connect the inlet of a suitable regulator to the gas use valve or a transfer line from this valve to an appropriate wall mounted regulator. Please note that the gas withdrawal valve will be labeled. The regulator should be designed for use with cryogens and adjustable over the desired pressure range.
- The outlet of the regulator is connected to the system receiving the gas using the appropriate transfer line – in this case it's a dedicated gas line.
- Next close the regulator valve and open the gas use valve. Adjust the gas regulator to deliver the gas at the desired pressure, for example, 90 pounds per square inch. At this point you may begin withdrawing gas.
- In applications where large volumes of gas will be withdrawn from the container, the pressure building valve will be opened. This valve operates an internal circuit that allows more liquid to vaporize then would naturally occur through evaporation alone. The vendor supplying the container generally knows your application and opens or closes this valve when delivered.

Dispensing - Dewar (less than or equal to 50 liters) to smaller container

Prior to dispensing cryogen from one Dewar to a smaller container make sure you are wearing safety glasses, long pants without cuffs, closed-toed shoes, a laboratory coat and cryogen gloves. If you have the potential to be splashed in the face, add a face shield. Now it's time to pour. Add the liquid slowly and pour directly into the mouth of the receiving container. The rapid vaporization of the cryogen as it comes in contact with the receiving container chills the container, but if added too quickly splashing will result. After the rapid vaporization has decreased in the receiving container, you can fill it at the normal rate. Pouring liquid cryogens from a height above waist level should be avoided whenever possible. If you must do this be sure your eyes, face and body are protected from splashes. And make sure your gloves extend over your lab coat sleeves.

Some Dewars in the 25 to 50 liter size range can be fitted with a liquid withdrawal device that clamps onto the neck flange of the Dewar. These devices allow a small pressure to build within the container (approximately 10 pounds per square inch) that is used to force liquid cryogen out of the spout and phase separator when a valve is opened. A face shield and cryogen gloves should be worn when filling small Dewars with this type device.

Transporting large liquid containers and Dewars

Large liquid containers

The large liquid containers on campus are equipped with wheels and are always rolled in their upright position. Before moving a container check to see that the wheels are firmly attached and in good condition. Containers have fallen over during transport when wheels have fallen off.

When transporting large liquid containers you must wear steel toed shoes. Tennis shoes and open toed shoes are not proper foot protection!! Containers can cause crushing injury to the feet. Containers should always be moved by pushing the container, never pulling it. This reduces the possibility of the container falling on you or a coworker. Larger containers should be handled by two people. Wheeled containers should also not be moved up or down ramps by laboratory personnel. The forces required to control a container on a ramp increase dramatically as does the risk of a spill or other incident. Finally, watch out for uneven floor surfaces which can catch a wheel and cause the container to overturn. Consider walking the route you will be traveling to be sure there is a smooth path of travel before moving the container. If you must move a container over a lip or uneven surface, perhaps while loading it on an elevator, rotate the cylinder in circular fashion over the lip one wheel at a time.

Dewars
In most cases, large Dewars (greater than 5 liters) with wheels can safely be moved from the cryogen filling station to the lab. But watch out, the wheels are generally small and can catch on uneven floor surfaces, causing the Dewar to overturn.

Elevators: Additional Safety Precautions
The transportation of cryogenic liquids in elevators represents a potential asphyxiation risk if researchers become trapped in an elevator with a container of cryogen. When possible use a freight elevator to transport a cryogenic liquid between floors. If a passenger elevator must be used, people must not ride with the container. To accomplish this safely two people must work together. The first person places the container on the elevator along with a clearly visible sign warning staff and students not to enter the elevator with the container. The elevator is sent to the appropriate floor. The second person meets the elevator on its arrival, removes the container and signage and returns the elevator to normal service.

Shipping with cryogens
Special shipping containers, cooled with liquid nitrogen, are used when shipping some biological material. Special training is required to package the material properly, chill these containers and complete the necessary shipping papers. If you plan to use this shipping technique, contact the EHS Office to arrange the necessary training.

Disposing cryogens
You should dispose of cryogenic liquids by allowing them to evaporate in a chemical fume hood or under other local exhaust ventilation. Never dispose of liquid cryogens down the drain. Plumbing associated with laboratory sinks is not able to withstand cryogenic temperatures and will crack or break.

We are close to the finish line. We will now explore our final topic - how we should respond to emergencies involving cryogens.

Section 6: Emergency response procedures
Responding to spills of cryogens
If you experience any of the following conditions you must notify your coworkers and leave the area immediately. There may be an oxygen-deficient atmosphere.

- A spill of one or more liters in a small space
- A spill of ten or more liters in a laboratory
- A popping sound (like the bursting of a balloon) and continuous gas release from a liquid container's rupture disk (not a pressure relief valve), and
- An oxygen monitor alarming.

Block access to the area after evacuating and notify your supervisor and the EHS Office immediately for additional guidance. The Emergency Response Guide poster found in your laboratory contains the appropriate calling instructions. Remember, oxygen-deficient atmospheres have no warning properties.

Responding to cryogen exposures and first aid
Splash skin exposure to a liquid cryogen usually causes only a first degree burn because the liquid runs off of and evaporates quickly from the skin. These exposures generally do not require treatment unless blisters appear on the skin. If blisters appear seek, medical attention and evaluation.

Immersion into liquid cryogen or trapping the cryogen against the skin for longer periods (perhaps because it gets caught in clothing) can cause frostbite and tissue death. Medical attention and evaluation should be sought immediately. Gradual rewarming of the affected tissue with tepid water is usually indicated. Do not rub the skin which may damage it.

Splashes to the eye are very serious and immediate medical attention should always be sought to minimize the potential for loss of sight.

Anyone showing symptoms associated with a lack of oxygen, as identified on this graph, should be moved immediately to an area with a normal atmosphere. Before assisting anyone found collapsed or unconscious in an area handling cryogens, you must make sure that an oxygen deficient atmosphere does not currently exist. This can be done with a stationary or portable oxygen monitoring device. Many oxygen deficient atmospheres resulting from cryogen spills quickly return to normal. However, you must not enter an area potentially deficient in oxygen If you do not have, or do not know how to use an oxygen monitoring device, call campus police for immediate assistance. Emergency responders wearing self-contained breathing apparatus will initiate a rescue and provide medical assistance.

Once again, The Emergency Response Guide poster found in your laboratory contains the appropriate calling instructions for obtaining assistance for medical emergencies. And remember, you must report all accidents and exposures to your supervisor.

Section 7: Closure and quiz

This completes the cryogen safety training program. To summarize, in this training we reviewed the following:

- the primary hazards associated with cryogens and how to work with them safely
- the appropriate containers and equipment to use with cryogens
- the types of personal protective equipment to wear when handling cryogens
- the procedures to follow when dispensing cryogens and transporting them, and
- the procedures to follow in the event of a large spill or if one is splashed with a cryogen.

To obtain credit for participating in this training program you must take a short quiz. Once you have taken and passed the quiz your participation will be automatically recorded. You can start the quiz by selecting the “take the quiz” button.

Post quiz results…
Pass Quiz
Thanks for participating in this training and your interest in our environment, health and safety programs. Your quiz results have been automatically recorded.

A handout is linked at the bottom of this slide which summarizes the content of this training. We encourage you to download a copy and save it to your computer or print it for future reference. We have also assembled a set of reference materials for handlers of cryogens on the EHS Office's web site. You can access this web-page by clicking on the link provided below. We encourage you to bookmark this page for future reference.

If you have any questions about working safely with cryogens, contact the EHS Office.

Fail Quiz

Welcome back. You have two options for getting credit for this course. You can retake the quiz immediately by clicking on the "take the quiz" button below. Or, if you prefer to review some of the course's content before retaking the quiz you can do this by using the table of contents on the left hand side of the screen. When you are ready to retake the quiz simply select the quiz link at the bottom of the table of contents.

Acknowledgements..

Some of the content include in this training program were obtained from the sources listed below and we appreciate their consent to include it. We would also like to acknowledge the contributions of the individuals listed below in the development of this program. Their input made this a much better, more focused training program.