

**STUDY MATERIAL FOR THE  
CERTIFICATE OF FITNESS FOR  
CONSOLIDATED EXAM FOR:**

**G-97**

**This Study Material includes the following:**

**G-15 USE OF LIQUID O<sub>2</sub> ON WORK SITE**

**G-28 STORAGE AND USE OF CRYOGENIC/REFRIGERATED  
LIQUID GASES**

**G-41 AND G-50 SUPERVISION OF COMMERCIAL CRYOGENIC/  
REFRIGERATED SYSTEMS (O<sub>2</sub>, N<sub>2</sub>O, CO<sub>2</sub>, N<sub>2</sub>, AR)**

**G-49 TRANSFILLING OF CRYOGENIC/REFRIGERATED  
LIQUID GAS CYLINDERS**

**G-51 USE OF CRYOGENIC INERT GASES ON WORK SITE**

**ALSO INCLUDED IN THIS BOOKLET YOU WILL  
FIND THE FOLLOWING:**

**1. NOTICE OF EXAMINATION (NOE) (R-10/27/99)**

**Note: Applicants are advised to review HANDBOOK OF COMPRESSED GASES 2<sup>nd</sup> Ed.  
By The Compressed Gas Association, Inc.**

This study material, in addition to any other information you have obtained, will help you prepare for the examination for the Certificate of Fitness for the supervision of commercial cryogenic/refrigerated systems and the storage and handling of cryogenic/refrigerated liquids. A Certificate of Fitness holder is required to be physically present on the premises at all times the system is in operation.

The study material includes information taken from the Fire Prevention Code and the Rules of the City of New York. The study material does not contain all the information you need to know in order to perform your job. In addition to the study material, it is important that you familiarize yourself with all applicable rules and regulations of the city of New York, even if they are not covered in this study material.

### Sample Questions:

- \_\_\_\_\_1. What sports team plays at Shea Stadium in New York?  
(A) Mets.  
(B) Giants.  
(C) Jets.  
(D) Cardinals.

The correct answer is "A". You would mark "A" on your answer sheet.

- \_\_\_\_\_2. Who was the first President of the United States?  
(A) George Jefferson.  
(B) George Washington.  
(C) Bill Clinton.  
(D) George Bush.

The correct answer is "B". You would mark "B" on your answer sheet.

## **CRYOGENIC/REFRIGERATED LIQUIDS**

All cryogenic fluids are extremely cold. Cryogenic/refrigerated liquids and their cold "boil-off" vapors can quickly freeze human tissue and cause many common materials such as carbon steel, plastics, and rubber to become brittle, or even fracture under stress. Liquids in poorly insulated or non-insulated containers and/or piping at temperatures at or below the boiling point of liquefied air (-318° F, -194° C) can actually condense the surrounding air to a liquid. This liquid air is oxygen-rich and should be treated as liquid oxygen. The extremely cold liquefied gases (LHe, LNe) can even solidify exposed air or other gases.

All cryogenic liquids produce large volumes of gas when they vaporize. For example, one volume of liquid nitrogen at its boiling temperature at 1 atm vaporizes to 700 volumes of nitrogen gas when warmed at room temperature at 1 atm. The volume expansion ratio of oxygen is 860.6 to 1. Liquid neon has the highest expansion ratio of any industrial gas at 1500 to 1. If these liquids were vaporized in a sealed container, they would produce enormous pressures. Pressurized cryogenic/refrigerated containers are protected with multiple devices for pressure relief; usually a pressure relief valve for primary protection, and a frangible disc for secondary protection.

Most cryogenic/refrigerated liquids are odorless, colorless and tasteless when vaporized to the gaseous state. Most of them have no color as a liquid, although liquid oxygen is light blue. However, the extremely cold liquid and vapor has a built-in warning that appears whenever they are exposed to the atmosphere. The cold boil-off gases condense the moisture in the air, creating a visible fog. The fog normally extends over a larger area than the vaporizing gas.

All of the gases except oxygen can cause a person to suffocate by replacing breathable air in an enclosed workplace. However, workers will not be aware of the presence of such gases without a tool to help them detect the gases. Therefore, they can be suffocated before they realize that the problem exists.

## **SAFETY PRACTICES**

Always handle cryogenic/refrigerated liquids carefully. At their extremely low temperatures, they can produce frostbite on the skin and exposed eye tissue. When spilled, they tend to cover a surface completely, cooling a large area. The vapors from these liquids are also extremely cold. Delicate tissues, such as those of the eyes, can be damaged by exposure to these cold gases, even when the contact has been so brief to affect the skin of the hands or face. Stand clear of boiling or splashing cryogenic/refrigerated liquids and their vapors. Boiling and splashing always occurs when charging a warm container, or when inserting warm objects into a liquid. Always perform these operations slowly to minimize boiling and splashing. If cold liquid or vapor contacts the skin or eyes, follow with first aid.

Never allow any unprotected part of the body to touch uninsulated pipes or vessels which contain cryogenic/refrigerated fluids. The extremely cold metal will cause the flesh to stick fast and tear when one attempts to withdraw from it. Even nonmetallic materials are dangerous to touch at low temperatures. Use tongs to withdraw objects dipped in a cryogenic/refrigerated liquid. Objects that are soft and pliable at room temperature, such as rubber or plastics, are easily broken because they become hard and brittle at extremely low temperatures. Carbon steels also become brittle at low temperatures and will easily break.

In the event of unlikely contact with a cryogenic/refrigerated liquid or cold gas, a cold-contact burn may occur, which means that the skin or eye tissue freezes. If this should occur, remove any clothing that may restrict the blood circulating to the frozen area. Do not rub frozen parts because the tissue may become damaged. Obtain medical assistance as soon as possible. Place the affected part of the body in a warm water bath, which has a temperature of no less than 105° or more than 115° Fahrenheit. Never use dry heat. If possible, put the victim in a warm room. If there has been massive exposure so that the general body temperature is lowered, the patient must be re-warmed by putting him/her into a warm water bath. Supportive treatment for shock should be provided.

Frozen tissues are painless and appear waxy with a possible yellow color. They will become swollen, painful and can become infected when thawed. Do not re-warm rapidly if the accident occurs in the field and the patient can not be transported to medical attention immediately. Thawing may require from 15 to 60 minutes and should be continued until the pale blue hue of the skin turns pink or red. Narcotics such as morphine or tranquilizers may be required to control the pain during thawing and should be given only under professional medical supervision. If the frozen part of the body has thawed by the time the medical attention has been obtained, cover the area with dry sterile dressings or with a large bulky protective covering. Alcoholic beverages and smoking decrease blood flow to the frozen tissue and should not be used. Warm drinks and food may be given to a conscious victim.

The best investment in safety is trained personnel. Some personnel need only detailed training for a particular type of equipment, cryogen or repair operation. Others require broader training in safe handling practices for a variety of cryogenic/refrigerated fluids.

Persons who work with cryogenic/refrigerated liquids, including handling, storage, and transfer operations should be trained in the:

1. nature and properties of cryogenics in both liquid and gaseous phases;
2. specific instructions on the equipment to be used;
3. approved materials that are compatible with the cryogens;
4. use and care of protective equipment and clothing;
5. safety, first aid, and self aid when first aid and/or medical treatment is not available;
6. handling emergency situations such as fire, leaks, and spills;
7. good housekeeping practices are essential for the safety of personnel.

## **PROTECTIVE CLOTHING AND EQUIPMENT**

Eye and hand protection for handling cryogenic/refrigerated liquids should be used by all workers with any chance of exposure to liquids or boil-off vapors. Appropriate eye and hand protection serves primarily to protect workers against splashing and possible cold contact burns. Safety glasses are recommended during transfer and normal handling of cryogens. If severe spraying or splashing may occur, a face shield or chemical goggles should be worn for additional

protection. Insulated gloves should always be worn when handling anything that comes in contact with cold liquids and vapors. Gloves should be loose fitting so that they can be removed quickly if liquids are spilled into them. Trousers should be left outside of boots or work shoes.

## VENTILATION

Ruptures of containers, pipelines or systems, and suffocation are the primary hazards of inert gas systems. A cryogen cannot generally be maintained as a liquid even in well-insulated containers. Any liquid or even cold vapor trapped between valves has the potential to cause an excessive pressure buildup to the point of violent rupture of a container or piping. Therefore, the use of reliable pressure-relief devices is required. Safety and relief devices should be replaced and/or adjusted only by authorized personnel familiar with the equipment.

Loss of vacuum in vacuum-jacketed tanks containing cryogenic liquids will cause increased evaporation within the system. This may cause the relief devices to work and result in product venting. The vented gases should be routed to a safe outdoor location. If outdoor venting is not done, the user must assure himself/herself that enough ventilation is maintained.

All gases should be used and stored in well-ventilated areas. Oxygen is the only gas that will support life. High concentrations of all other gases reduce the breathable oxygen in the air below a safe level. All entrances to such areas should have prominent durable signs indicating danger due to extreme cold and possibility of rapid suffocation. Suffocation can occur suddenly or slowly without the worker being aware that he/she is in trouble. The problem is easily avoidable unless large quantities of inert gas are present. This can be done by using proper ventilation at all times. When it is absolutely necessary to enter a work area that may have an oxygen content below 19%, by volume, portable air packs or a hose mask connected to a breathing-air source must be used. An absorptive gas mask will not prevent suffocation. The following provisions must be kept in mind when ventilation for a working cryogenic environment is being considered:

1. the normal oxygen concentration in air is about 21% by volume and provides a safe working environment with respect to oxygen required to support life.
2. depletion oxygen in a given volume of air by combustion, can be remedied by replacement with inert gas or by increased elevation. The true measure of oxygen availability is the oxygen partial pressure. While the percent of oxygen in the atmosphere is always 20.9% at all elevations, the partial pressure of oxygen in the atmosphere varies with the ratio of the atmospheric pressure at the elevation being considered, to the atmospheric pressure at sea level.
3. when the oxygen content of air is reduced to 15 to 16%, the flame of ordinary combustible materials, including those commonly used as fuel for heat or light, will be extinguished. Below this concentration an individual breathing the air is mentally incapable of figuring out the situation as the symptoms of sleepiness, fatigue, weariness, loss of coordination, errors in judgement, and confusion will be masked by a state of "euphoria" giving the victim a false sense of security and well being.
4. human exposure to atmospheres containing 12% or less oxygen will bring about unconsciousness without warning and so quickly that the individual cannot help or protect himself/herself. This is true if the condition is reached by immediate change of

environment or by gradual depletion of oxygen. The victim's condition and degree of activity will have a noticeable effect on signs and symptoms at various oxygen levels. In some instances, prolonged reduction of oxygen may cause brain damage if the individual survives. Areas where it is possible to have low oxygen content must be well ventilated. Nitrogen vents must be piped outside of buildings to safe areas. Where low oxygen atmospheres are possible installation of analyzers with alarms should be used. Constant monitors, sniffers, and other precautions must be used to check atmospheres and maintain surveillance when personnel enter such enclosed areas or vessels. If used, a sensor should be mounted approximately five feet above the floor for proper determination of oxygen concentration. When there is any doubt of maintaining safe breathing atmospheres, an oxygen mask or approved air lines must be used.

## HANDLING RECOMMENDATIONS

Cryogenic/refrigerated liquids are stored and transported in a wide range of containers, from small Dewars to railroads tank cars. Depending on the type, the vessel must be approved by the US Department of Transportation, the New York City Board of Standards and Appeals, or the New York City Fire Department before it can be used within New York City. Use only equipment and containers designed for the intended product and service pressure, and temperature. If there are any questions as to the correct handling or transport procedure, or harmony of materials with a given cryogenic/refrigerated liquid, ask your gas supplier. Cryogenic/refrigerated liquids ordinarily should not be handled in open containers unless they are made for that purpose and for the specific product. Containers must be clean, constructed from materials suitable for cryogenic temperatures such as austenitic stainless steels, certain nickel bearing steels, cooper or certain aluminum alloys. Most other materials become brittle at cryogenic temperatures.

Personnel should have proper training and instructions for the specific cryogen and equipment involved. Transfer of cryogens into warm lines or containers should be done slowly to prevent thermal shock to the piping and containers and possible excessive pressure buildup within the system. When transferring liquid from one container to another, the receiving container should be cooled slowly to prevent thermal shock and to avoid splashing. High concentrations of escaping gas should be vented. Do not drop solids or liquids into cryogenic/refrigerated fluids. Violent boiling can splash liquid onto personnel and equipment.

Avoid breathing vapors from any cryogenic/refrigerated liquid source, except from liquid oxygen equipment designed to supply breathing oxygen. When releasing cryogenic/refrigerated liquids from drain valves or blowdown lines, open the valves slowly to avoid being splashed by cold liquid. Do not smoke, or permit smoking or open flames in any area where flammable liquids, gases or liquid oxygen are stored, handled or used, or where they are loaded and/or unloaded. Post "**NO SMOKING**" signs that are readily seen and read in these areas.

Portable cylinders for cryogenic/refrigerated liquids are pressurized containers, usually vertical vessels, designed and manufactured in accordance with DOT-4L specifications. Cylinders specifically designed for liquid helium are also available. There are three major types of cryogenic/refrigerated liquid cylinders: one used for dispensing of liquids or gases; one used for gas withdrawal only, and one for liquid withdrawal only. Each type of cylinder has valves for filling and dispensing product, and valve and frangible disk against cylinder over-pressurization. All valve outlet connections should be in accordance with industry for the product being stored.

Cryogenic/refrigerated liquid cylinders of various sizes can be moved by hand but it is better to move them using a portable handtruck. A strap should be used to secure the cylinders to the handtruck so as to avoid the cylinders from slipping off. Cryogenic/refrigerated liquid containers and cylinders should not be dropped or tipped over on their sides.

A cold outside jacket on a cryogenic/refrigerated liquid receiver can indicate the loss of insulating vacuum, although frosting is usually observed on the exterior of some types of portable vessels when product is being withdrawn at a high rate. Portable vessels suspected of vacuum loss or other defects should be removed from service and set aside. Only an authorized company with qualified service personnel, usually the supplier of the cryogen, should perform repairs to portable vessels, permanently fixed receivers, and cryogenic/refrigerated systems.

Some build-up of frost is not uncommon on those portions of systems containing or exposed to cryogenic/refrigerated liquids or cold gases. In addition to possibly preventing safety devices from operating, frost build-up reduces heat transfer through the frosted surface, and can affect the motion of moving parts. Excessive frosting can be minimized by following the operating instructions provided by the equipment manufacturer or cryogen vendor. Frost build-up should be removed only as directed in the operating instructions or by authorized service personnel.

## **FIRE PREVENTION AND FIRE FIGHTING**

The location and maintenance of fire safety and fire fighting equipment is important. All valves and controls should be properly and permanently labeled so as to permit a safe shut down in the event of an emergency. All personnel must be informed of all necessary safeguards before entering a potentially hazardous area. One of the special problems with cryogenic/refrigerated liquids that make fire fighting more difficult is their potential to rapidly freeze water. On one hand, the use of water on surfaces of cryogenic/refrigerated containers or piping can lead to heavy icing and possible blockage of pressure relief devices. On the other hand, relatively warm water will cause the liquefied gas to vaporize more rapidly.

There are no general safety objections to using carbon dioxide (CO<sub>2</sub>) extinguishers to fight smaller cryogenic/refrigerated liquid fires. However, the operation of CO<sub>2</sub> extinguishers may create electrostatic discharges that may ignite some hydrogen/air mixtures. CO<sub>2</sub> extinguishers are ineffective with oxygen-rich fires. After large volumes of cryogenic/refrigerated substances being released into the atmosphere, a fog will form from water vapor condensing in the surrounding air. This fog may severely reduce visibility. Escape routes in potentially vulnerable areas should include blind reference points such as handrails (about 4 feet high), and simple solid object such as curbs to permit location and identification by hand alone.

It is not possible to outline specific fire fighting techniques that will cover all types of fires involving cryogenic/refrigerated liquids. Such techniques may include the location of the fire with respect to adjacent areas and their occupants as well as other factors.

Everyone not actively engaged in fighting the fire should leave the area. Occupants should be evacuated well outside the fire area. If electrical equipment is involved in the fire, be sure that the power supply is disconnected before using water for fire fighting or else use carbon dioxide or dry chemical fire extinguishers. When using water, use large quantities in spray form, to cool equipment in the areas surrounding the fire. Use the spray to cool any burning material below its ignition temperature. If possible, do not spray cold areas of equipment, or direct water onto the

cryogenic/refrigerated fluid. If an inert cryogenic/refrigerated liquid is involved judgment should be used in deciding whether to allow the gas to escape- with possible risk of suffocation of firefighters- or to cut off the gas flow. Where suffocation is not a factor, it is wise to reduce the pressure at the source of the inert cryogenic/refrigerated fluid.

Nitrogen, argon, and other inert gases are non-combustible; that is, they do not present a fire hazard. However, if a system should rupture due to a fire, these gases may displace air to the point where there is not enough oxygen to support life. Excessive pressure build-up in piping and storage vessels can be prevented through proper selection of pressure-relief devices and flow control equipment.

## FIRE EXTINGUISHING DEVICES

### Types of Fires

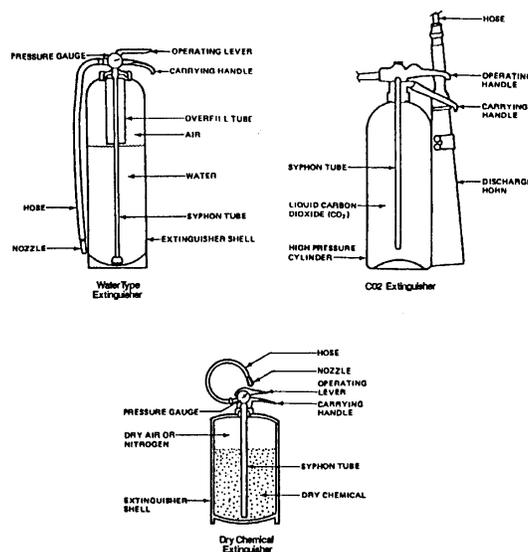
**Class A** fires are caused by ordinary combustible materials (such as wood, paper, and cloth), for which the quenching-cooling effect of quantities of water or solutions containing large percentages of water is most effective in reducing the temperature of the burning material below its ignition temperature..

**Class B** fires are caused by flammable petroleum products or other flammable liquids, greases, etc., for which the blanketing-smothering effect of oxygen-excluding media such as CO<sub>2</sub>, dry chemical or foam is most effective.

**Class C** fires involve electrical equipment. The electrical non-conductivity of the extinguishing media is of first importance. These fires must be extinguished with non-conductive media such as CO<sub>2</sub> or dry chemical.

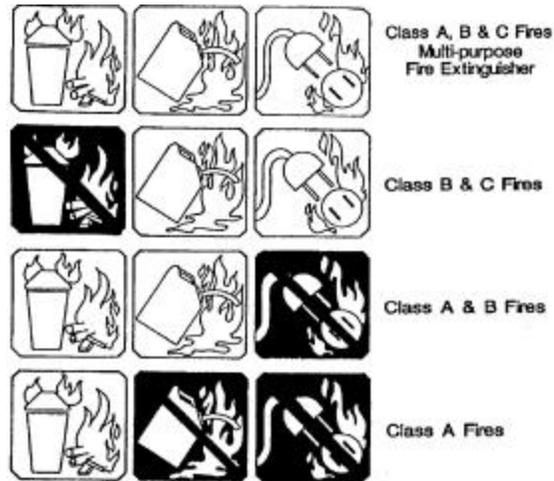
**Class D** fires are caused by ignitable metals, such as magnesium, titanium, and metallic sodium, or metals that are combustible under certain conditions, such as calcium, zinc, and aluminum. Generally, water should not be used to extinguish these fires.

A multi-purpose dry chemical fire extinguisher may be used to extinguish Class A, B, or C fires. Examples of Water type, CO<sub>2</sub> and Dry Chemical extinguishers are shown below.



## TYPES OF FIRE EXTINGUISHERS

Symbols may also be painted on the extinguisher. The symbols indicate what kind of fires the extinguisher may be used on. Examples of these symbols are shown below.



### Fire Extinguisher Identification Symbols

The symbol with the shaded background and the slash indicates when the extinguisher must not be used. The Certificate of Fitness holder must understand these symbols. All fire extinguishers should be kept in good working order at all times.

Usually operating instructions are clearly painted on the side of the fire extinguisher. They describe how to use the extinguisher in case of a fire emergency. An example of these instructions is shown below.



### Fire Extinguisher Inspections

The Certificate of Fitness holder must make sure that the fire extinguishers are visually inspected regularly. When a damaged extinguisher is discovered it must be repaired or replaced immediately. Care must be taken to make sure that all the fire extinguishers are fully charged. This is checked by looking at the gauge connected to the top of the extinguisher. A needle indicating the condition of the extinguisher is positioned inside the gauge. When the needle points to the green area the extinguisher is fully charged. When the needle points to the red area the extinguisher must be recharged. The Certificate of Fitness holder must make arrangements to recharge the extinguisher when necessary. A qualified technician must recharge the extinguishers. All extinguishers must be tested at least once every six months and recharged once a year by a qualified technician. The testing date and the technicians name must be recorded on a tag attached to the extinguisher. All inspections must be recorded in the inspection log.