



## GC CONNECTIONS

# Laboratory Gas Safety

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You have purchased a new gas chromatograph. Your company's safety office has completed a review of your lab's supplies. Before setting up your gas chromatograph, you read the instructions and familiarize yourself with the instrument. You might even give some thought to the exposure risks for the various substances in your samples. Yet, what about the less visible risks inherent in the gas delivery system that makes this a gas chromatograph?

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**L**aboratory gases, as with most laboratory supplies, have risks that must be understood to use them effectively. This column will provide an overview of safety information, especially for the gases used in gas chromatography (GC).

First, require that all employees who might encounter the gas cylinders read and understand the Materials Safety Data Sheets (MSDS) for each gas and gas mixture. Also, make sure they are familiar with the labeling on the cylinders. Every cylinder delivered to your laboratory must bear clear labeling, according to the United States Department of Transportation — which regulates compressed cylinders. Cylinder color should never be used to identify contents. A shoulder label should indicate the product's shipping name and identification number. On pure products, a grade label also is applied. The shoulder label identifies the cylinder contents. Labeling also must have one or more of the hazardous materials diamonds as outlined by 49 CFR 173 and HM 126f.

The most common laboratory gases are:

- carrier gases — helium, nitrogen, and hydrogen;
- flame ionization detection (FID) gases — hydrogen, hydrogen mixtures, other fuel gases, and air;
- supercritical and coolant gases — liquid nitrogen and carbon dioxide;
- inductively coupled plasma (ICP) gases — argon, compressed and in liquid form;
- electron-capture detection and nuclear counter mixtures — methane-argon mixtures; and
- atomic absorption (AA) gases — nitrous oxide and acetylene.

Next, educate your employees so that they understand the five main hazards associated with laboratory gases.

### Pressure-Related Dangers

The U.S. DOT considers all compressed gases hazardous, simply because they are under pressure. Most cylinders of laboratory gases, such as helium, hydrogen, and gaseous nitrogen, are delivered with 2000–2400 psig of pressure. Some gas cylinders are shipped with as much as 10,000 psig. A cylinder with a damaged valve can take off like an unguided missile. If the cylinder itself is damaged — by an electric arc, for instance — it can explode, sending shrapnel across the laboratory.

Even downstream from the cylinder, pressure dangers remain. Each valve, regulator, pipe, connection, and fitting must be rated to handle the applied pressure at that point in the gas delivery system. Valves provide flow control and regulators reduce gas pressures to safe working levels. The Compressed Gas Association (CGA) has specified standard outlet fittings for valves and regulators to avoid connections of the wrong gas. Bypassing or modifying the regulator, or a regulator failure, could cause a system rupture. Installers should construct systems with check valves and pressure-relief devices even if local codes do not require them, to reduce the chances of pressure-related problems.

When using liquefied gases, it is important not to trap any liquid between two valves. As gases vaporize, they expand many times, which could result in a pressure rupture. Also, when switching gas supplies from liquid to high-pressure cylinders, keep in mind that a system designed for a liquid dewar of argon at only 22 psig will not handle the much



**Figure 1:** Make sure cylinders are secured properly at all times in a rack or with a chain, both in storage and at the laboratory workbench.

higher pressures of a gaseous supply adequately.

### Asphyxiation

Simple asphyxiation is a primary hazard associated with most gases. Because inert gases are colorless and odorless, they can escape into the atmosphere undetected and quickly reduce the concentration of oxygen below life-sustaining levels. Yet, keep in mind that all gases, with the exception of compressed air and oxygen, pose this danger.

Liquefied gases pose an added asphyxiation risk because they produce large volumes of gas when they vaporize. If a sufficient amount of liquid is vaporized, particularly in a confined space, it will create an oxygen-poor environment quickly. For example, a small spill of liquid nitrogen expands to 696 times its liquid volume when it vaporizes. In a confined space, this would pose an immediate health hazard. Use and store liquid cryogenics in well-ventilated areas and vent exhaust streams to safe locations.

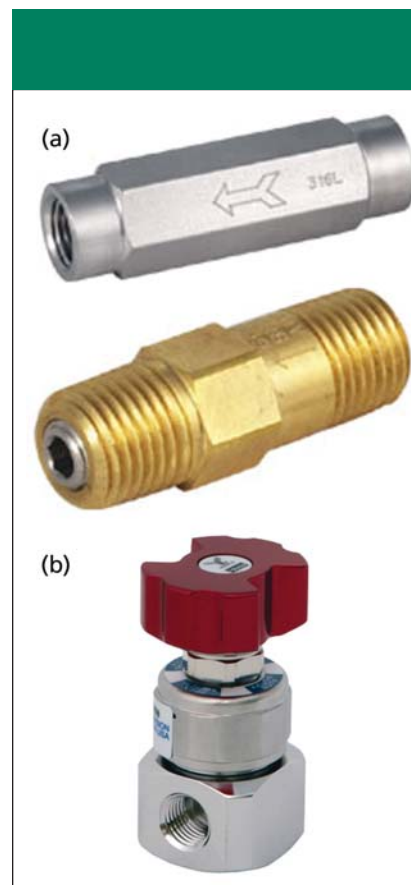
End-users should monitor oxygen levels in areas of cryogen use and in enclosed areas where gases are used and stored. Never enter an area where oxygen levels are below 19.5%. If the oxygen concentration in the room falls below

19.5%, personnel should deploy and don self-contained breathing apparatuses (SCBA). Transport of cryogenic containers in elevators should be avoided unless absolutely necessary. If an attendant must be in the elevator, the worker should have an escape pack with supplemental breathing apparatus and no other personnel should be in the car.

### Fire and Explosion

Fire and explosion are the primary hazards associated with flammable gases, as well as oxygen and other oxidizing gases. Any heat source, such as a flame or a hot object, or even static electricity, can ignite flammable gases. Oxygen and other oxidizing gases do not burn but will support combustion of flammable materials. Increasing the concentration of an oxidizer accelerates the rate of combustion. Materials that are nonflammable under normal conditions can burn in an oxygen-enriched atmosphere.

The most common flammable gases in the laboratory are acetylene used in AA and hydrogen used as a carrier gas or as a detector gas in FID, flame photometric detection, and thermionic or nitrogen-phosphorus detection. And do not forget any propane on hand for flame photometry. Nitrous oxide in AA is an example of an oxidant.



**Figure 2:** (a) Installers should construct systems with check valves and pressure relief devices to reduce the chances of pressure-related problems. (b) An excess flow shut-off valve will automatically shut off the delivery of gas if it exceeds a preset limit.

### Temperature Danger

Gases delivered in low-pressure cryogenic dewars pose a risk of cryogenic freezing. Make sure that all gas users know the temperatures of the various liquefied gases with which they will be working. In the laboratory, the most common examples are liquid argon,  $-186\text{ }^{\circ}\text{C}$  ( $-302\text{ }^{\circ}\text{F}$ ); liquid nitrogen,  $-196\text{ }^{\circ}\text{C}$  ( $-320\text{ }^{\circ}\text{F}$ ); and liquid helium,  $-269\text{ }^{\circ}\text{C}$  ( $-452\text{ }^{\circ}\text{F}$ ). Carbon dioxide, though not a cryogenic gas, is also hazardous when the liquefied compressed gas evaporates, at about  $-78\text{ }^{\circ}\text{C}$  ( $-109\text{ }^{\circ}\text{F}$ ). Unlike the

other liquefied gases, which create relatively low tank pressures, liquid carbon dioxide creates a tank pressure of over 900 psig at room temperature and requires a regulator capable of handling the higher pressure.

Laboratories must take adequate precautions to protect workers who handle cryogenics. Due to their extremely cold temperatures, cryogenics will freeze human tissue rapidly. Therefore, insulated gloves approved for use in cryogenic service must be worn when operating valves, or when the potential exists for contact with

### **Here are some other simple tips for proper storage and usage of cylinders**

- Always store cylinders in the upright position in their assigned area.
- Close gas cylinder valves when going on breaks and at the end of the day.
- When opening a cylinder cap or valve, never force it open with pliers or other tools. Call your supplier if either is jammed.
- Protect the cylinder from excessive heat, arcs, open flames, and mechanical shocks, such as being hit or toppled.
- Make sure cylinders are insulated and never grounded or part of an electrical circuit.
- Check cylinders regularly for leaks and other damage.
- Keep cylinders free of any grease or oil.
- Separate oxidizers, combustible materials, and flammable gas storage areas by at least 20 ft or by a noncombustible wall of fire-resistant construction.

the cryogen product or exposed cold piping. Gowns, safety glasses, and face shields also should be worn to prevent injury to the face and eyes. Transfer lines should be approved for use with cryogenics and should have a phase separator to help prevent cryogen splashing.

### **Transportation and Storage Hazards**

Handling cylinders requires special attention to safety. At as tall as 5 ft and 500 lb empty, a falling cylinder can injure employees or result in a broken valve. Therefore, make sure cylinders are secured properly at all times in a rack or with a chain, when they are in storage and at the laboratory workbench.

When moving a cylinder, close the main cylinder valve, remove any regulator, and replace the protective valve cap before moving and during storage. This will prevent the valve from being sheared off should the cylinder topple, turning a harmless looking cylinder into a projectile that can penetrate concrete walls. Never lift a cylinder by the valve cap, as

the threads are not designed to handle the load. Never use slings or magnets to assist with a cylinder transfer. The proper way to move a cylinder is by using the appropriate gas cylinder cart.

Beyond educating personnel on these hazards, there are a number of other steps you should take toward full safety preparedness:

**Have an emergency plan:** Emergency plans are essential to safe laboratory operations. Review the plan and practice emergency drills regularly so both are up

to date. Inform personnel of the potential hazards of the gases with which they are working and train them to carry out emergency plans and first aid procedures. Inform local hospitals, fire departments, and other local emergency response organizations of the gases in use so that they, too, will be prepared in the event of an emergency.

**Enforce the "dress code:"** Require personnel to wear suitable protective clothing, including gloves, eye protection, and face protection. Keep in mind that a face shield alone is not adequate



**Figure 3:** Laboratory workers who handle cryogens must wear insulated gloves, gowns, safety glasses, and face shields to prevent injury to the face and eyes.

protection for the eye and should always be used with protective eyewear. Safety equipment, such as self-contained breathing apparatus and fire extinguishers, should be located near hazardous areas.

**Follow the rules:** Follow all federal, state, and local regulations pertaining to the storage and use of compressed gas cylinders. CGA Pamphlet P-1 provides excellent guidance. Follow the National Fire Protection Association (NFPA) codes, especially for flammable products.

**Tap the expertise of your supplier:** Talk to your local gas suppliers to be sure that they are equipped to respond to any emergency involving the products they provide and for correct handling and storage procedures. They also should be able to explain what emergency-response services are available locally. Most gas companies have their own emergency response teams trained to respond to the specific risks of cylinder gases. Most supply companies also have technical sup-





**Figure 4:** The proper way to move a cylinder is by using the appropriate gas cylinder cart. Always replace the cylinder cap before transport.

port lines to answer nonemergency technical questions, which is especially helpful during the set up of a laboratory.

Almost all the suppliers post safe-handling information online.

In conclusion, compressed and lique-

fied gases offer a safe and economical form of gas supply to laboratory applications. With proper use, these gases will help your new GC system improve your laboratory's productivity as well as the other important "P's" for your operations: proactive education of employees prepares them, and in turn, prevents accidents.

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