IX. COMPRESSED GASES

Many laboratory operations require the use of compressed gases for analytical or instrument operation purposes. Compressed gases present a unique hazard in that they can pose both physical and health hazards (depending on the particular gas). The gases may be flammable, combustible, explosive, corrosive, poisonous, inert, or a combination of different hazards. Asphyxiation can also be caused by a high concentration of "harmless" gases such as nitrogen. Finally, the large amount of potential energy resulting from compression of the gas makes a compressed gas cylinder a potential rocket or fragmentation bomb. In any case, the gases are contained in and used from heavy, highly pressurized metal containers. Thus, careful procedures are necessary for handling the various types of compressed gases, the cylinders that contain them, the regulators or valves used to control their flow, and the piping used to confine them during flow.

A. Identification

1. All compressed gas cylinder should be clearly identified so that the contents can be easily, quickly, and completely determined by any employee. Such identification should be stenciled or stamped on the cylinder itself or a label should be provided that cannot be removed from the cylinder. No compressed gas cylinder should be accepted for use that does not legibly identify its contents by name. Color coding is not an acceptable means of identification, since cylinder colors vary from supplier to supplier and labels on caps have no value since caps are interchangeable. If the labeling on a cylinder becomes unclear or an attached tag is defaced so that the contents cannot be identified, the cylinder should be marked "contents unknown" and returned directly to the supplier.

2. All gas lines leading from a compressed gas supply should be clearly labeled so as to identify the gas, the laboratory served, and relevant emergency telephone numbers. The outlets should be clearly labeled as to the type of gas that is contained in them. The labels should be color coded to distinguish hazardous gases such as flammable, toxic, or corrosive substances (e.g., a yellow background and black letters).

3. Signs should be conspicuously posted in areas in which flammable compressed gases are stored, identifying the substances and appropriate precautions (e.g., HYDROGEN - FLAMMABLE GAS - NO SMOKING - NO OPEN FLAMES).

4. Signs should be conspicuously posted in areas in which oxygen cylinders are stored, identifying oxygen is present and appropriate precautions (e.g., OXYGEN - NO SMOKING - NO OPEN FLAMES).

B. Handling and Use

1. Compressed gas cylinders **must** be secured at all times to prevent them from tipping over. They may be attached to a bench top, individually to the wall, in a holding cage, to some form of solid support, or have a non-tip base

attached. If a cylinder should fall and the valve become damaged, the cylinder could become a missile, causing considerable physical damage or harm.

2. When new cylinders are received, they should be checked to see that they have the proper cap securely in place, and that there are no leaks present. Leaks can be detected with soap solution or "snoop." If leaks are found, remove the cylinder to a safe place and inform the vendor as soon as possible. Under no circumstances should any attempt be made to repair a cylinder or valve.

3. Cylinders containing flammable gases such as hydrogen or acetylene must not be stored in the close proximity of open flames, areas where electrical sparks are generated, where other sources of ignition may be present, or where oxygen cylinders are stored or used. An open flame should never be used to detect leaks of flammable gases. All cylinders containing flammable gases should be stored in a well-ventilated area.

4. Oxygen cylinders that are full or empty must not be stored in the same vicinity as flammable gas. Greasy and oily materials must never be stored around oxygen. The proper storage for oxygen cylinders requires that a minimum of 20 feet be maintained between flammable gas cylinders and oxygen cylinder storage, or that the areas be separated by a minimum of a fire wall that is five feet high and has a fire rating of 0.5 hours.

5. Cylinders containing gases with an NFPA Health Hazard rating of 3 or 4, gases with an NFPA Health Hazard rating of 2 without physiological warning properties, and pyrophoric gases should be kept in a continuously mechanically ventilated hood or other continuously mechanically enclosure. A continuous gas detection system that provides an alarm to warn of the presence of toxic gases in levels that present a hazard to life is required.

6. Always use safety glasses, or preferably a face shield, when handling and using compressed gases, especially when connecting and disconnecting compressed gases since pressurized leaks almost always spray into the eyes.

7. Cylinders should be placed so that the valve is accessible at all times. It is never necessary to open the main cylinder valve all the way; the resulting flow will be much greater than one would ever want. It is safe practice to open the main valve only to the extent necessary. The main cylinder valve should be closed as soon as it is no longer necessary that it be open (i.e., it should never be left open when the equipment is unattended or not operating). This is necessary not only for safety when the cylinder is under pressure, but also to prevent the corrosion and contamination that would result from diffusion of air and moisture into the cylinder after it has been emptied.

8. Cylinders in the laboratory should be equipped with a pressure regulator designed for the specific gas and marked for its maximum cylinder pressure, and, should be attached to an instrument for use by means of a regulator. The regulator system should be equipped with two gauges, installed so as to show both the cylinder pressure and the outlet pressure.

    a. Always make sure that the regulator and valve fittings are compatible. The threads on cylinder valves, regulators and other fittings should be examined to ensure that they correspond to one another and are undamaged.

    b. After the regulator is attached, the cylinder valve should be cracked just enough to indicate the pressure of the regulator (no more than one full turn) and all the connections should be checked with "snoop" for leaks. Never use oil or grease on a regulator or cylinder valve.

9. Piping material must be compatible with the gas that is being supplied. No copper is to be used for acetylene and no plastic piping for any portion of a high pressure system. If there is any question as to the suitability of a regulator or piping material for a particular gas, contact the vendor.

10. Cylinders not “in use” should not be stored in the laboratory. A compressed gas cylinder is considered to be “in use” if it is connected through a regulator or to a manifold being used to deliver gas to a laboratory operation, or is a single cylinder secured alongside one that is connected and serves as the reserve cylinder (only one reserve cylinder allowed per connected cylinder).

11. A cylinder should never be emptied to a pressure lower than 172 kPA (25 psi) because the residual contents may become contaminated if the valve is left open. When the cylinder needs to be removed or is empty, all valves should be closed and the regulator removed. The valve cap should be replaced, the cylinder should be clearly marked as "empty," and should be returned to a storage area for pickup by the supplier.

12. Liquid bulk gas cylinders may be used in laboratories where a high volume of gas is needed. These cylinders usually have a number of valves on the top of the cylinder. These valves should be clearly marked as to their function. These cylinders will also vent their contents when a preset internal pressure is reached, therefore, they should be stored or placed in service where there is adequate ventilation. See also Section IX. D. *Cryogenic Liquids*.

13. Observe the following special rules when working with acetylene cylinders.

    a. Acetylene cylinders are partially filled with acetone; always store then upright.

    b. Do not use an acetylene cylinder which has been stored or handled

in a non-upright position until it has remained in an upright position for at least 30 minutes.

c. Ensure that the outlet line of an acetylene cylinder is protected with a flash arrester.

d. Never exceed the pressure limit indicated by the warning red line of an acetylene pressure gauge.

e. Use the correct kind of tubing to transport the gaseous acetylene. Tubing materials such as copper and some brass alloys form explosive acetylides.

Sources: *Chemical Safety Manual for Small Businesses*, 2nd Ed., American Chemical Society, 1992
NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, 2000
NFPA 55, *Standard for the Storage, Use and Handling of Compressed and Liquified Gases in Portable Cylinders*, 2000

C. Transportation of Cylinders

The cylinders that contain compressed gases are primarily shipping containers and should not be subjected to rough handling or abuse. Such misuse can seriously weaken the cylinder and render it unfit for further use or transform it into a rocket having sufficient thrust to drive it through masonry walls.

1. To protect the valve during transportation, the cover cap should be screwed on hand tight until the cylinder is in place and ready for actual use.

2. Cylinders should never be rolled or dragged.

3. When moving large cylinders, they should be strapped to a properly designed wheeled cart to ensure stability.

4. Only one cylinder should be handled at a time.

D. Cryogenic Liquids

A number of hazards may be present from the use of cryogenic liquids in the laboratory. Employees should be properly trained in these hazards prior to use and 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 the operation.

1. Neither liquid nitrogen nor liquid air should be used to cool a flammable mixture in the presence of air because oxygen can condensate from the air and lead to potentially explosive condition.

2. Adequate ventilation must always be used to prevent the buildup of vapors of flammable gases such as hydrogen, methane, and acetylene, which could create an explosive or hazardous condition.

3. Adequate ventilation is also required when using gases such as nitrogen, helium, or hydrogen. In these cases, oxygen can be condensed out of the atmosphere creating a potential for explosive conditions.

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 prevent the possibility of thermal expansion and the resulting bursting of the vessel by hydrostatic pressure.

5. Appropriate containers must be used that will withstand the temperatures and that are impact resistant.

6. Always handle cryogenic liquids carefully. Even very brief contact with a cryogenic liquid is capable of causing tissue damage similar to that of thermal burns, and prolonged contact may result in blood clots that have potentially very serious consequences. In addition, the surfaces they cool can cause severe damage to the skin upon contact. The vapors from cryogenic liquids are also extremely cold, which can damage the eyes and mucous membranes. Therefore, gloves and eye protection, preferably a face shield, should be worn at all times when handling cryogenic liquids. Gloves should be chosen that are impervious to the fluid being handled and loose enough to be tossed off easily. Appropriate dry gloves should be used when handling dry ice, which should be added slowly to any liquid portion of the cooling bath to avoid foaming over.

7. Stand clear of boiling or splashing liquid and its vapors. Boiling and splashing always occur when charging a warm container, or when inserting warm objects into a liquid. Always perform these operations slowly to minimize boiling and splashing.

8. Store liquid nitrogen, liquid helium, dry ice and any other liquefied gases in well-ventilated areas. Do not store in walk-in cold rooms as these are not well ventilated.

9. As the liquid form of gases warm and become airborne, oxygen may be displaced to the point that employees may experience oxygen deficiency, or asphyxiation. Any area where such materials are used should be well ventilated. For this same reason, employees should avoid lowering their head into a dry ice chest as carbon dioxide is heavier than air, and suffocation can result.

Sources: *Handbook of Compressed Gases*, Second Edition, Compressed Gas Association, 1981
Chemical Safety Manual for Small Businesses, Second Edition, American Chemical Society, 1992