Compressed Gases

Compressed gases are defined as materials that fit into any of the following categories.

1. Any material or mixture in a container with an *absolute pressure* exceeding 40 psi (276 kPa) at 21°C (70°F).
2. Any material or mixture in a container with an *absolute pressure* exceeding 104 psi (717 kPa) at 54°C (130°F).
3. Any liquid flammable material having an absolute vapor pressure exceeding 40 psi (275 kPa) at 38°C (100°F).

These are often grouped by similar properties. *Nonliquefied gases* are gases with low boiling points. These include common materials such as nitrogen, oxygen, and helium. Some of these are present in liquid form at "cryogenic" temperatures, and are used in the liquefied state. These are known as *cryogenic fluids*. *Liquefied gases* have higher boiling points, and include such common materials as propane, carbon dioxide, and chlorine. Acetylene is the only widely used *dissolved gas*. It is supplied in an acetone solution.

Hazards and General Precautions

Compressed gases often represent multiple hazards. These gases are under tremendous pressure, and can produce unexpected propulsion in improperly controlled situations. Additionally, these gases may quickly disperse into the lab atmosphere. This may produce a danger of asphyxiation or toxic effects (for some gases). Cryogenic gases present unique hazardous properties, which include pressure buildup, embrittlement of materials in contact, frostbite, and asphyxiation. Additionally, oxidizers or flammable gases present severe fire or explosion hazards in cryogenic form.

Proper use of compressed gases requires that you be familiar with procedures for their safe handling. All departmental employees are required to view the film *Working With Compressed Gas* as part of initial safety training. Additional "one-on-one" training should be provided for those transporting or using compressed gases for the first time (or until proficient in the required skills).

The following general precautions apply to all compressed gases.

1. Never drop cylinders or allow them to strike other objects with force.
2. Leave the cylinder cap on until the cylinder has been secured and is ready for use.
3. Use an appropriate cart to transport cylinders. Cylinder should be secured to the cart to move. Do not attempt to roll, drag, or slide cylinders.
4. Do not tamper with safety devices on cylinders, regulators, valves, or associated systems.
5. Do not subject compressed gas cylinders to temperatures exceeding 52°C (125°F). Never allow a flame to contact a compressed gas cylinder.
6. Use compressed gases only in well ventilated areas. Use a fume hood when handling toxic, corrosive, or flammable gases.

7. Use the smallest cylinder size available that is adequate for your application. This is especially important when working with toxic materials.
8. When discharging gas into a liquid, use a trap or check valve to prevent liquid from backing into regulator or cylinder.
9. Refer to the label information and MSDS before handling any compressed gas. Know the specific hazards of the material and obtain proper personal protective equipment before proceeding with use.
10. Cylinders stored outside for an extended time present an inviting environment for wasps and similar insects. Use extra caution when removing a cap from a cylinder that you suspect has been stored outdoors.
11. Turn off the cylinder valve for cylinders not in use.

Some hazards associated with specific gases are listed in Table 1. Many of these are used at MSU. An explanation of the categories is given below.

Oxidant

These gases will initiate and support combustion. When using oxidants, no sources of ignition should be present. Oxidants should be stored away from combustible materials. Oil, grease, and other combustibles should never be used on oxidant cylinders, regulators, or other fittings.

Inert

Inert gases are inherently unreactive. However, in a confined area, an inert gas can displace air and cause asphyxiation. Inert gases should be used only in well ventilated areas.

Corrosive

Corrosive gases may cause damage to equipment and may cause injury to persons exposed. These gases should be used in a fume hood. Proper selection of materials used to handle these gases will reduce the associated hazards. Some anhydrous gases display corrosive properties only in the presence of air or water.

Flammable

Flammable gases, mixed with air or other oxidants, will burn or explode upon ignition. When using flammable gases, no sources of ignition should be present. Flammable gases should be stored away from oxidants. Table 1 lists the limits of flammability for some common gases. Within the range listed, gas/air mixtures may be ignited (at ambient temperature and atmospheric pressure). Mixtures above or below the range listed do not ignite. Follow general handling precautions for using flammable materials when working with these gases. Remember that concentrations of these gases may quickly reach limits of flammability.

Bond and ground cylinders, lines, and equipment in service with flammable gases. Usually, this is accomplished by using metal (conductive) lines to interconnect the system. Use of plastic lines or tubing without separate bonding could result in static charge generation.

Because of the extreme ignition characteristics of acetylene, it is supplied dissolved in acetone. To avoid the presence of acetone in the gas exiting the cylinder, don't allow the tank pressure to fall below about 50-75 psi. Acetylene should never be used at pressures exceeding 15 psi. Acetylene may form explosive compounds with copper, silver, and mercury. Avoid contact with these materials in systems using acetylene. Acetylene cylinders should remain upright at all times, and should be opened only about 1½ turns in use.

Toxic

Several gases listed are toxic. Significant health effects or death may result from exposure. Although some gases may be detected visually or by odor, others present no warning of their presence (for instance, carbon monoxide). Toxic gases should be handled in an operating fume hood. The values listed are exposure limits established by OSHA, NIOSH, or other agencies. The values are expressed as *TWA* (time weighted average - maximum exposure allowed over a 10-hour day, 40-hour week), *Ceiling* (exposure not to be exceeded any time), or *STEL* (short term exposure limit - maximum exposure over a fifteen-minute period.)

Cryogenic

Access to cryogenic materials is restricted to personnel with proper training in their proper handling. Materials of construction used to contain cryogenic fluids must withstand extremely cold temperatures without embrittlement or other damage. Containers and systems must have pressure relief mechanisms to avoid dangerous buildup of pressure. Cryogenic fluids in contact with skin or eyes will produce tissue damage very quickly. When handling or transferring cryogenic fluids, wear splash goggles and impervious insulated gloves that can be removed easily. In addition, the use of a face shield is recommended. In procedures where splash or spray of the fluid is possible, wear an impervious apron or coat, trousers without cuffs, and high topped shoes. Pot holders should be available for some operations.

Table 1. Properties of Common Compressed Gases

Name	*Formula*	*M.W.*	*CAS #*	*Oxidant*	*Inert*	*Corrosive*	*Flammable (limits of flammability, vol %)*	*Toxic (exposure limits, ppm)*	*Valve Outlet, CGA*	*Comments*
Acetylene	C_2H_2	26.04	74-86-2				2.5-100	2500 Ceiling	300	1½ turns max. on cylinder valve. *Do not* use copper (or brass >65% Cu) tubing or fittings. *15 psig max.*
Air	Components, mole %: 78.09 N_2, 20.95 O2, 0.93 Ar, 0.03 CO_2								590	
Argon	Ar	39.95	7440-37-1		X				580	
Carbon Dioxide	CO_2	44.01	124-38-9		X			5000 TWA	320	
Carbon Monoxide	CO	28.01	630-08-0				12.5-74	35 TWA	350	
Chlorine	Cl_2	70.91	7782-50-5	X		X		0.5 Ceiling	660	
Helium	He	4.00	7440-59-7		X				580	May be supplied as a cryogenic fluid.
Hydrogen	H_2	2.02	1333-74-0				4.0-75		350	
Nitrogen	N_2	28.01	7727-37-9		X				580	May be supplied as a cryogenic fluid.
Nitrogen Dioxide/ Nitrogen Tetroxide	NO_2/ N_2O_4	46.01 92.01	10102-44-0	X		X		1 STEL	660	
Nitrous Oxide	N_2O	44.01	10024-97-2	X				25 TWA	326	
Oxygen	O_2	32.00	7782-44-7	X					540	
Propane	C_3H_8	44.10	74-98-6				2.1-9.5	1000 TWA	510	
Sulfur Hexafluoride	SF_6	146.07	2551-62-4		X			1000 TWA	590	

Cylinder Storage

Secure all compressed gas cylinders. Since a single cylinder strap will not always hold a cylinder upright in an earthquake, a dual restraint is advised. The primary strap or chain should support the cylinder about a third of the distance down from the top. A secondary support near the cylinder base provides best seismic protection. Cylinder caps should be on all cylinders not in use.

Cylinder storage must be segregated based on cylinder contents. A separate storage facility must be available for *empty* and *full* cylinders. Flammable gases may not be stored with oxidants. We have elected to provide separate storage for flammable gases. Oxidizing gases are stored with other inert gases.

Cylinder Exchange

1. Do not drain the cylinder "dry." Leave about 25-100 psi of gas. A truly "empty" cylinder will allow ambient air to leak in, contaminating the next tankful.

2. Close the main valve, usually by turning clockwise from above. It should <u>not</u> take all your strength to close the valve properly. Bleed off any excess pressure; both gauges of the regulator should read zero. Close the second stage of the regulator (usually turn the T-handle counterclockwise).

3. Remove the regulator with an adjustable wrench. Vise-Grips are not recommended, as they damage the nut. The direction you need to turn depends on the gas tank. Argon, helium, and nitrogen turn "right," while hydrogen and acetylene turn "left." To check, you may look closely at the part of the thread you can see.

4. Cap the tank and label it with an "EMPTY" tag. You may now remove the tank from its clamp on the bench. Place it in a proper cart for transporting to the storage area. Be sure to chain the tank into the cart; even an empty tank is a hazard if it is dropped.

5. Chain the empty tank into its place in the storage area. Never leave the tanks unchained.

6. Pick up a full tank and fill in the sign-out sheet (usually inside the storage area door). Again, chain the tank into place on the cart. If for some reason the tank has no cap, be sure to put one on it before moving the tank. When a full, uncapped tank falls, the valve can break off. If this happens, it may go through a brick wall, since the gas exits with a thrust of over one ton!

7. Take the tank to the workplace and strap it into place. Never work with an unsecured tank of gas. You'll need to jockey the tank around so the outlet points in the proper direction for the regulator, before you strap it in.

8. After the tank is strapped in place, remove the cap. At this point, it is a good idea to "crack" the valve slightly (appropriate only for inert gases). This will blow out any dirt or dust in the outlet that would otherwise clog the regulator.

9. Replace the regulator. A regulator does NOT need Teflon tape at the tank. The seal is between the end of the brass "nipple" of the regulator and the inlet seat on the tank. The thread does NOT seal the joint. If the joint between regulator and tank leaks after being tightened properly, the inlet nipple probably needs to be replaced, or the inside of the valve is dirty. Take it off, wipe out the valve seat, and try again.

   If you hold the regulator aligned properly with the valve, you can "spin" the nut almost tight with your fingers. Then use the adjustable wrench to snug it down. Use one hand, not two, and just a bit of muscle. A good snug fit is all you should need.

10. Open the tank valve. A half turn or a full turn is enough. You should see at least 2000 psi on the first stage gauge. If not, the regulator may be faulty. Remove it and crack the valve a bit. If gas comes rushing out under high pressure, the regulator is bad. If not, someone may have returned an empty tank to the "Full" rack.

11. Set the second stage pressure by turning the T-handle clockwise, slowly. Estimated pressure requirements for common applications are: about 50 psi for gas chromatographs, 35 psi for compressed air or nitrous oxide (atomic absorption), 10 psi for acetylene (also for AA). Listen for leaks. Note that static pressure will be higher than flowing pressure. That is, once you open the valve to your instrument, the gauge pressure will probably drop. If you need a particular pressure, you may have to screw in the T-handle a bit more.

Regulators and Fittings

Label each regulator with the gas it is used for, and never use it for any other gas. Don't attempt to adapt one type of regulator to another type of tank, or you may risk an explosion. This is especially true for hydrogen regulators, which tend to adsorb hydrogen gas. If they're switched to an oxygen tank, a violent reaction can occur that blows off the regulator and tank valve. To prevent this sort of mishap, different types of gas use different types of regulators, and they're not normally interchangeable. These are specified by the Compressed Gas Association and are normally expressed as "CGA" numbers. Table 1 includes standard regulator specifications for common gases used at Murray State. *Never* oil any compressed gas regulator.

When you are running gas lines and need to use fittings, be sure that the fittings are properly mated. Basic types of fittings are: pipe thread (usually slightly tapered); compression (hardware store); compression (Swagelok or other commercial type); ISO (like pipe thread, but straight instead of tapered). Male and female threads should fit together easily. If they jam after one turn, they may not be the same type of fitting. For instance, 1/4" and 6 mm compression fittings look the same, but they are different enough to damage the threads if you try to mix them.

Teflon tape is only needed for pipe threads or similar tapered threads and should not be used on compression fittings. A fitting that will not seal without tape should be replaced. Read the instructions that came with the fittings and use them properly. A properly installed Swagelok fitting can be finger-tightened to stand up to 100 psi. If you think there is a leak, use soapy water to locate it. A little extra tightening may be all you need.