COMPRESSED GAS SAFETY

Policies and Procedures for Handling Compressed Gases

Chemical and Lab Safety Program
Environmental Health and Safety

UNIVERSITY OF
South Carolina

ABOUT THIS TRAINING

Please plan to review this training during normal business hours. If at anytime during the training you have questions, contact Jocelyn Locke at jlocke@mailbox.sc.edu or (803) 777-7650.

Take the quiz (link in the last slide) to measure your understanding of this topic.

COURSE OVERVIEW

This course designed to provide U*of*SC faculty, staff and students with the necessary knowledge to minimize the risk of exposure and injury when handling compressed gases while performing their job duties.

This course is required for all research faculty, staff, and students prior to working with compressed gases. A refresher must be completed every two years thereafter.

Once you completed this course, you and your supervisor will sign a training document (see next slide).

TRAINING DOCUMENTATION

I, (Principal Investigator printed name and signature) _____ certify that the following lab personnel have completed the course on Compressed Gas Safety by viewing the PowerPoint presentation, asking questions about any item that was not clear, and passing the quiz. In addition, all lab personnel has received instructions and training on how to install gas systems from a competent individual in my laboratory.

Lab Personnel	Name	Date	Signature	Name and signature of gas system installation Trainer
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

COMPRESSED GASES: WHY SHOULD WE CARE?

- Compressed gases (CGs) are hazardous to personnel, property and the environment.
- As a lab user of CGs, you must follow:
  - policies and procedures for safe handling of CGs to ensure <u>your safety,</u> to protect U*of*SC property, and to protect our environment.
  - the NFPA 55 Standard for safe installation, storage, use, and handling of compressed gases and cryogenic fluids in portable and stationary cylinders, containers and tanks.

KNOWLEDGE AND SKILLS YOU NEED TO WORK WITH COMPRESSED GASES

Hazards of the gases you plan to use	Controls and precautionary measures	Procedures to follow if emergency arises (fire, gas leak, injury)	How to write a Standard Operating Procedures (SOP)
Basic knowledge of, cylinders, pressure regulators, fittings and tubings	How to install gas systems (properly attach regulator and install valves, tubing, fittings and connections)	How to adjust delivery pressure and flow rate	How, where, and when to test for leaks
How to purge gas lines	How to change out cylinders	How to store, secure, move, and “dispose” of cylinders	NFPA 55 Standard

COURSE MODULES

1. Hazards of Compressed Gases (CGs)
2. About Gas Cylinders
3. Planning to Use CGs
4. Installation of Gas Systems
5. Experimentation Using CGs
6. Handling CGs
7. Highly Hazardous Gases

MODULE 1

COMPRESSED GASES: WHY ARE THEY HAZARDOUS?

COMPRESSED GAS

A material or mixture that is:

i. a gas at 20ºC or less at an absolute pressure of 14.7 psi and

ii. that has a boiling point of 20ºC or less at an absolute pressure of 14.7 psi and that is liquefied, non-liquefied or in solution

iii. Packaged at >40.6 psi at 20ºC and has no other health or physical hazards

(As defined by NFPA 55 - Standard for the Storage, Use and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders and Tanks – 2020 Edition)

Risks to personnel and property

Physical

- heavy weight can cause serious pinch or crush injury
- release of pressure cuts through soft tissues and propel cylinders at high speed though ceilings and walls (video)
- many CGs exist in liquified, cryogenic state, which cause serious burns in contact with soft tissues
- ignition of flammable and pyrophoric gases cause fire
- oxidizing gases support accelerated combustion
- unstable reactive gases cause explosion

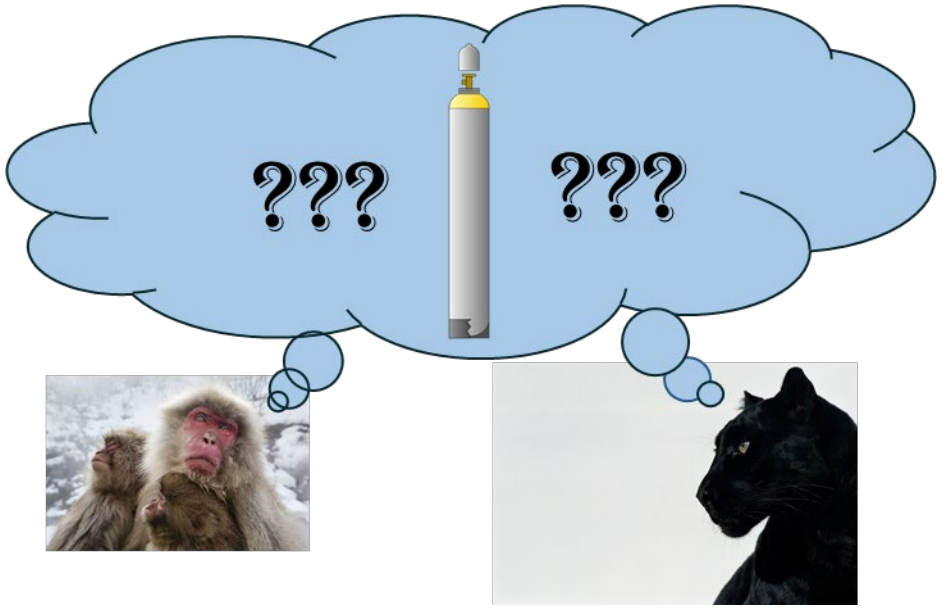
Health

- asphyxiation happens when gas molecules displace oxygen in air, making air unsuitable for breathing
- corrosive gases cause visible destruction of or irreversible alteration of tissues (skin, eyes, respiratory system) at the site of contact
- many gases are toxic or highly toxic to humans

Hazard classes of gases according to NFPA 55

Hazard Class	Characteristic
Inert Gas	Non-reactive, nonflammable, non-corrosive (Ar, He, Kr, Ne, N2 Xe)
Other Gas	NOT classified as corrosive, flammable, toxic, oxidizing, pyrophoric, or unstable reactive with hazard rating of Class 2, 3 or 4
Corrosive	Causes visible destruction of or irreversible alteration in living tissue by chemical action at the site of contact
Flammable	Ignitable at 14.7 psi when in mixture at 13% or less by volume with air, or has a flammable range at 14.7 psi with air of at least 12% regardless of the lower limit
Flammable Liquified	Liquified compressed gas, when under a charged pressure, is partially liquid at 68 deg F and is flammable
Highly Toxic	Has median LC_{50} in air of 200 ppm by vol or less of gas or vapor or 2 mg/L or less of mist, fume or dust
Oxidizing cryogenic fluid	An oxidizing gas in a cryogenic state
Oxidizing Gas	Support and accelerate combustion of other materials more than air does
Pyrophoric	Has auto-ignition temperature in air at or below 130 deg F
Toxic gas	Medial LC_{50} in air of more than 200 but less than 2000 ppm by vol. of gas or vapor, or more than 2 mg/L but no more than 20 mg/L of mist, fumes or dust
Unstable Reactive Gas	Vigorously polymerize, decompose or condense; become self-reactive or otherwise undergo a violent chemical change under conditions of shock, pressure or temperature

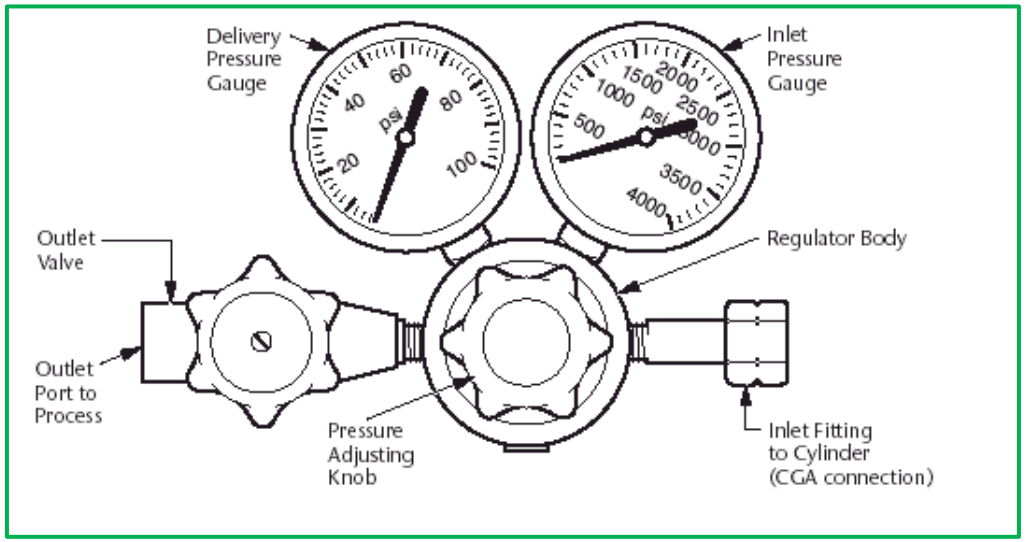
Module 2
Return to Module List

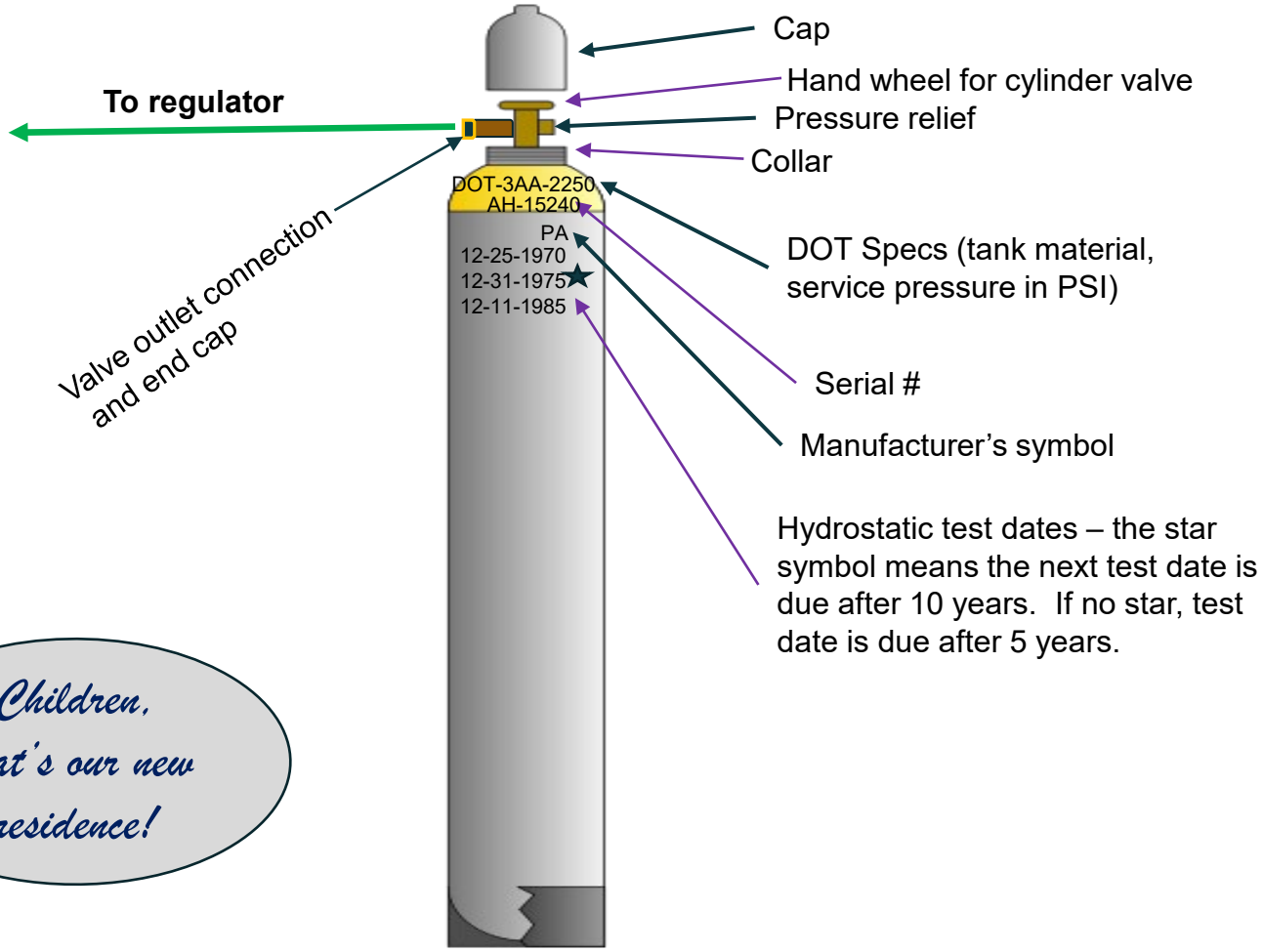


MODULE 2

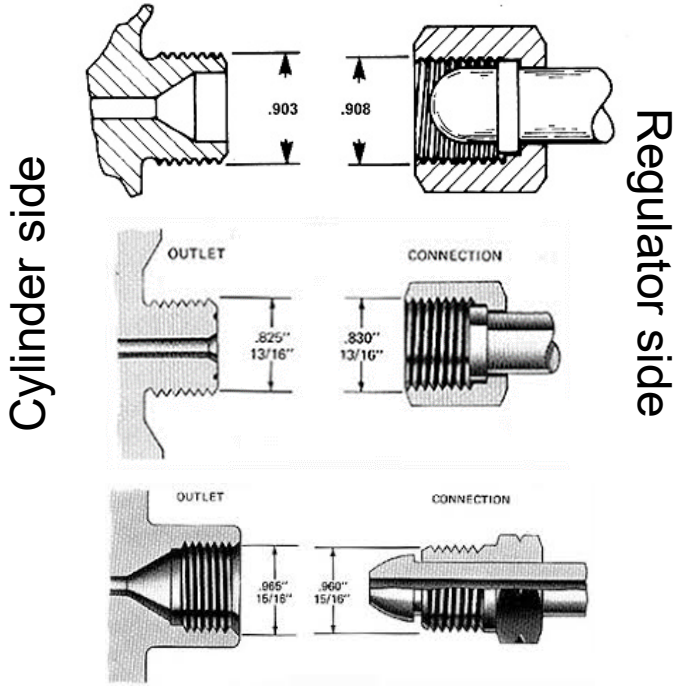
ABOUT GAS CYLINDERS

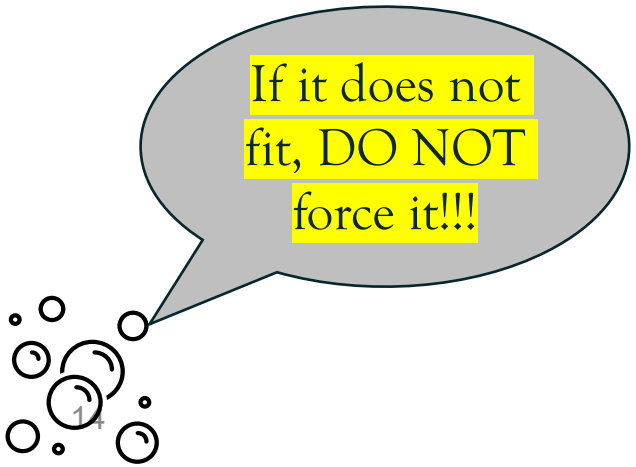
The Compressed Gas Cylinder





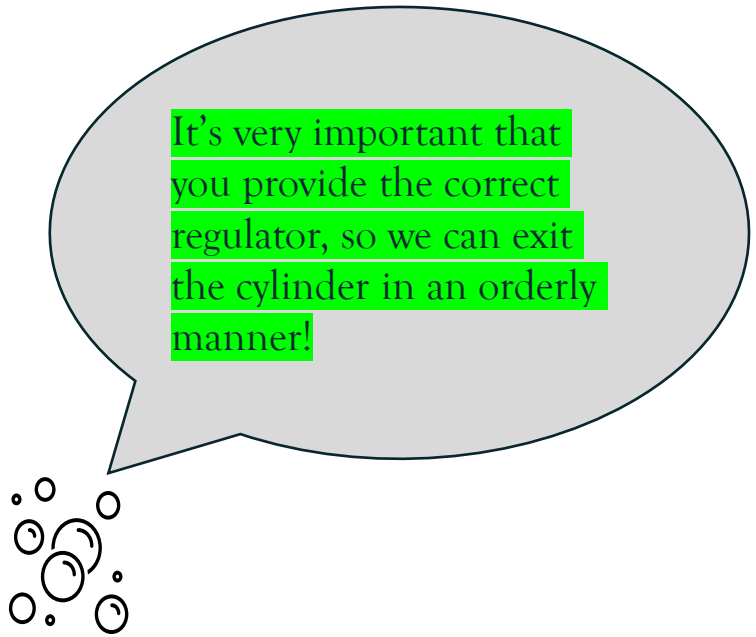
The Compressed Gas Association (CGA) developed a standardized valve inlet and outlet connections and regulator connections.





Regulators compatible with gas (cylinder) will have threads that match the cylinder valve outlet threads.

To choose the right regulator, consider the following:



- **CGA regulator fitted to the gas cylinder**
- **Incoming pressure** – maximum pressure handled by the regulator *vs*. cylinder pressure
- **Outgoing pressure** – pressure required by your system?
- **Regulator material** – chrome plated brass *vs.* stainless steel *vs.* other material
- **Dual stage *vs*. single stage** – based on the need for consistent outlet pressure

CGA Regulator ID for various gases (*partial list*).

Regulator Inlet Nuts & Nipples

- CGA-320 Carbon Dioxide
- CGA-326 Nitrous Oxide
- CGA-330 Non-Corrosive Gases
- CGA-346 Air
- CGA-346 Air Continued
- CGA-347 Air
- CGA-350 Hydrogen/Methane/Natural Gas
- CGA-410 Canadian Acetylene
- CGA-415 Canadian Acetylene
- CGA-500 Medical Mixtures
- CGA-510 Acetylene/Propane/Natural Gas
- CGA-520 “B Size” Acetylene in Small Cylinders
- CGA-540 Oxygen

Pin Indexed yokes

- CGA-870 Oxygen
- CGA-880 CO2/ Oxygen Mixture/ CO2 not over 7%
- iCGA-890 Helium/Oxygen Mixture w/ He Not over 80%
- CGA-910 Nitrous Oxide
- CGA-930 Helium/Oxygen Mixture w/ He Over 80%
- CGA-940 CO2/Oxygen Mixture w/ CO2 Over 7%
- CGA-950 Medical Air
- CGA-960 Nitrogen
- CGA-973 Medical Gas Mixtures

MODULE 3

I'M PLANNING TO USE COMPRESSED GASES: HOW SHOULD I PROCEED?

3.1. Know the general requirements.

- **Volume of gases (# cylinders**) - allowed limit would depend on reasonable quantities for in-use and needed back-up for immediate future use (consult EH&S)
- **Hazard signs added on to hazard notice -** corresponding with hazards of gases to be stored and/or used in the lab space
- **Hazard warning signages -** Flammable Gas, No Smoking, Keep Area Clear, *etc*.
- **Emergency Plan** – procedures for responding to releases, exposures, injury and fires
- **Inventory** – new gases added on to existing chemical inventory; include amount in cubic feet
- **Training** – prior to beginning work, users are given instructions on recognizing hazards, safe handling, storage and transport, safe use in experiments, proper response to releases and exposures, other instructions

3.2. How many cylinders should I order?

- **Flammables, oxidizers and inert gases**: purchase one cylinder of a unique gas for in-use (connected to a system/process) plus one back-up cylinder for that unique gas (to be stored in the lab). If more backups are needed, consult EH&S.
- **Flammable gases**: purchase at the most 2 cylinders of each unique gas to allow nearby labs to store and use flammable gases without exceeding allowable quantities within the fire control area.
- **Toxic, corrosive, pyrophoric, reactive gases**: purchase one cylinder of unique gas. If backups are needed, consult EH&S.
- **Multiple, manifolded, in-use cylinders**: purchase one set for the manifold and a backup set, if needed.
- Additional backup cylinders exceeding allowable storage in the lab should be stored in a designated cylinder storage room or a detached gas cylinder storage building.

3.3. Where should the vendor deliver the cylinders?

- Instruct vendor to deliver gas cylinders directly to the lab or to a designated gas cylinder storage room or detached building.

NOTICE: Do not purchase and have highly hazardous gases (toxic, corrosive, unstable reactive, pyrophoric) delivered to your lab without first consulting with EH&S.

3.4. Consult with Principal Investigator, peers, field experts, and EH&S.

Consultations should focus on identifying and evaluating:

- ❑ Hazards of gases
- ❑ Controls (downscaling, engineering, administrative, PPE, *etc*.)
- ❑ Reasonable volume and concentration
- ❑ Materials (regulators and accessories needed to secure, connect and withdraw gas from cylinder: CGA regulator, wall bracket, strap, tubing, leak test indicator, leak detectors, tools, washers, *etc*.)
- ❑ Containment and detection system required for corrosive, toxic, unstable reactive, and pyrophoric gases (may be required for flammable gases depending on location and use)
- ❑ Need for transport between rooms or instrument
- ❑ Need for written Standard Operating Procedures (SOP)
- ❑ Storage of backup cylinders
- ❑ Delivery and receiving
- ❑ Others

3.5. Identify, obtain, and put controls in place.

Controls should include the following:

- Substitution or downscaling
- Engineering – fume hood, gas cabinet, flashback arrestor, valves, detection system with auto shutoff, *etc*.
- Administrative and work practice – training, written Standard Operating Procedures, guidelines, universal precautions, *etc*.
- Personal protective equipment (PPE)
- Emergency response

3.6. Prepare documents.

Update chemical inventory to include purchased gases

SAFETY DATA SHEETS

Written Standard Operating Procedures (SOPs)

TRAINING CERTIFICATES

How to prepare written SOPs

1. Consult with Principal Investigator, coworkers, vendors, and other experts.
2. Review literature, SDSs, and other guidance materials.
3. Decide on what approach to take: specific substance, hazard class, process, others.
4. Use this SOP template and provide all required information in each section.
5. Prepare materials for the experiment then perform a dry run (substituting inert gas for hazardous gas).
6. Identify unsafe conditions and address them by adding controls. Revise SOP by incorporating new information.

NOTE: SOPs need to be written for the experiment/process as well as cylinder change-out.

More details and sample SOP:
https://sc.edu/about/offices_and_divisions/ehs/research_and_laboratory_safety/chemical_and_lab_safety/standard_operating_procedures/index.php

How to prepare a Chemical Inventory and find Safety Data Sheets

- Prepare an excel file that lists all the gases (each cylinder listed), the CAS number and the volume in cylinders.
- Visit the website of the manufacturer or supplier (i.e., **Airgas, Matheson, Praxair**) and search for the SDS of specific gas received.
- Print the SDS and keep alphabetically arranged in a binder for future reference.

Complete required trainings.

- Chemical and Laboratory Safety – all personnel, prior to them working in a research laboratory (every 4 yr.)
- Hazardous Waste – all personnel whose lab work will generate hazardous chemical waste (annual)
- Compressed Gas Safety (this Training) – all personnel who will work with compressed gases (every 2 yr.)
- Compressed gas system installation (hands-on) – provided by an experienced competent person designated by the PI (frequency as needed)

3.7. Obtain supplies.

- Personal protective equipment
- Gas cylinder securement
- Materials and tools for installing the gas system
- Tools to test for leaks
- Gas cabinet? Detection system?

etc.?

Personal protective equipment (PPE)

Eye protection

Hand protection

Skin protection

Foot protection

WOULD I NEED A RESPIRATOR?

<u>99% of the time NO!</u>

Engineering controls must be in place and designed to eliminate the risk of a hazardous gas escaping into the open lab BEFORE considering the use of a respirator.

Gas cylinder securement

Cage and wall mount

Bench clamp and floor stand

Tools and system components

Regulator, valves, washers

Fittings, tubing, leak tester, wrench

Do I need a gas cabinet?

NO, if using only gases that are	YES, if using gases that are
• inert • oxygen • 1-2 cylinder of flammable gas in use in an instrument	• toxic to highly toxic • corrosive • unstable reactive • pyrophoric

Gas cabinets: What are the requirements?

- Provided with an exhaust ventilation system designed to operate at a negative pressure relative to the surrounding area
- When containing toxic, highly toxic, pyrophoric, Class 3 or 4 Unstable Reactive or corrosive gases, the face velocity at access ports or windows must not be less than 200 f/min
- When containing toxic, highly toxic or pyrophoric gases – must be internally sprinklered
- No more than 3 cylinders, containers or tanks in one cabinet
- Incompatible gases must be in separate cabinets
- Label gas cabinet to indicate the gases inside

Do I need a detector?

NO, if using only gases that are	YES, if using gases that are
• inert • oxygen • 1 cylinder of flammable in-use for an instrument (detector required in Horizon)	• Flammable, in a process with: oxidizer, open flame, high temperature and/or pressure • toxic to highly toxic • corrosive • unstable reactive • pyrophoric

Module 4
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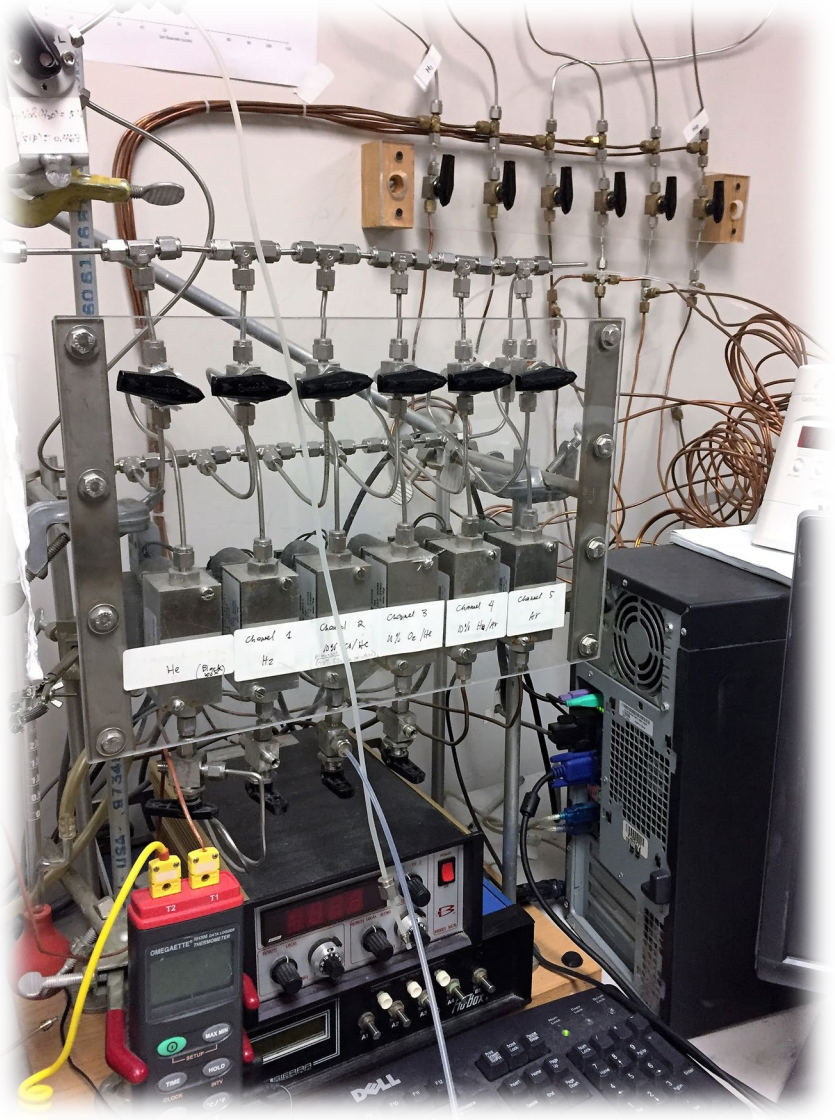
MODULE 4

INSTALLATION OF GAS SYSTEMS



4. INSTALLATION OF GAS SYSTEMS

This task is best learned hands-on with the instruction of an experienced and competent person.

However, there are important guidelines that you need to follow. Refer to the next 5 slides.

General guidelines for installing gas systems

- Labels and markings must be visible from any direction of approach.
- Use the correct CGA regulator for the gas cylinder.
- Choose the tubing, valves, fittings and connections that are compatible with the type of gas and that can withstand the pressure that the gas is released in the system.
- As much as possible, gas tubing must be run so that they are not hidden behind walls, ceilings and other obstructions.
- The system must be cleaned and purged with an inert gas prior to placing it in service.

DESIGNING GAS SYSTEMS

- Design controls to prevent gases from entering or leaving the process at an unintended time, rate and path.
- Design automatic controls so they are fail-safe.
- Use pipings, tubings, fittings, and related components that are designed, fabricated, and tested according to the requirements of the ASME B31.3.
- Piping, tubings, pressure regulators, valves, and other apparatus shall be kept gas-tight.
- Provide backflow prevention or check valves where backflow of hazardous gases can create a hazardous condition or cause releases.

DESIGNING GAS SYSTEMS (CONT…)

- Valves should be rated for intended pressure and should be accessible.
- Valve handles or actuators for shutoff valves should not be removed or otherwise altered to prevent access.
- Vent tubing termination – venting of gases should be done in a fume hood.
- Emergency shut-off valves – provide accessible manual or emergency shutoff valves to shut off the flow of gas in case of an emergency. Place emergency shutoffs at the point of use and at the tank.

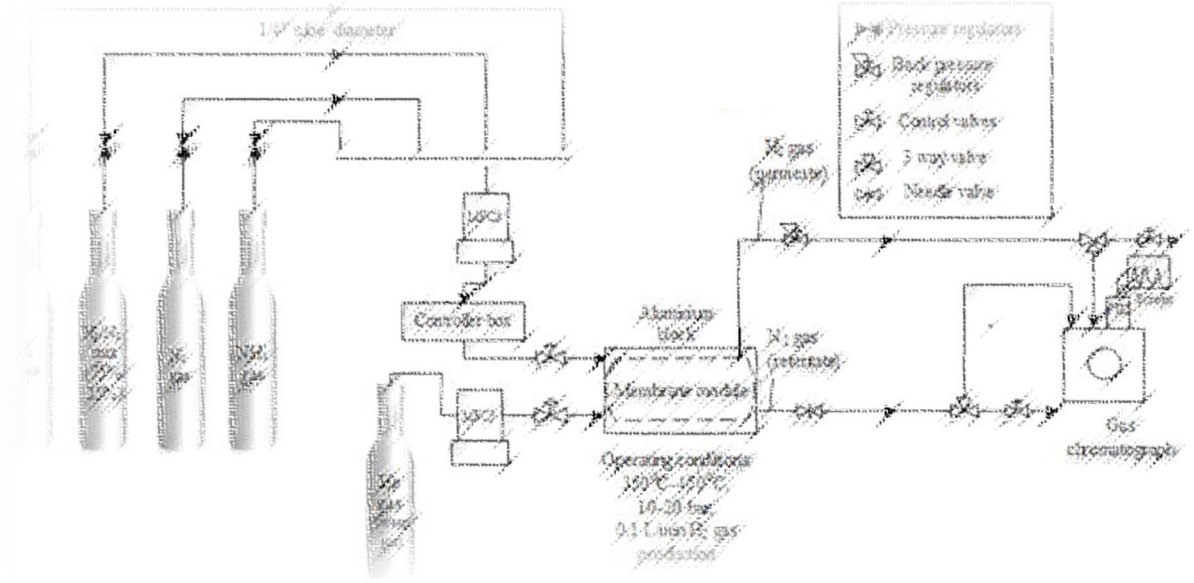
Gas lines or tubing

- Gas tubing must be marked with the name of the gas and the direction of flow.
- If conveying more than one gas at various times, provide clear identification and warning of hazard.
- Markings should be provided at the following locations:
  - at each critical process control valve
  - at wall or ceiling penetrations*
  - at each change of direction
  - at the minimum, every 4 feet or fraction thereof throughout the piping run

**All parts of a gas system need to be visible. Avoid installing gas lines behind ceilings and walls as much as possible.*

Cleaning and purging of gas lines

- When to clean and purge gas piping:
  - after installation and prior to placing them in service.
  - when changing the service of the tubings from one gas to another
  - every time the system is altered, repaired and/or parts replaced
  - when design or written procedures specify cleaning and purging
  - when deactivating or removing the tubings from service
- Written procedure must be established.
- Termination point for the release of purge gases shall be the chemical fume hood.



MODULE 5

EXPERIMENTATION USING COMPRESSED GASES: HOW SHOULD I PROCEED?

5. EXPERIMENTATION USING COMPRESSED GASES:

How do I perform this task safely?

While working with compressed gases, you must:

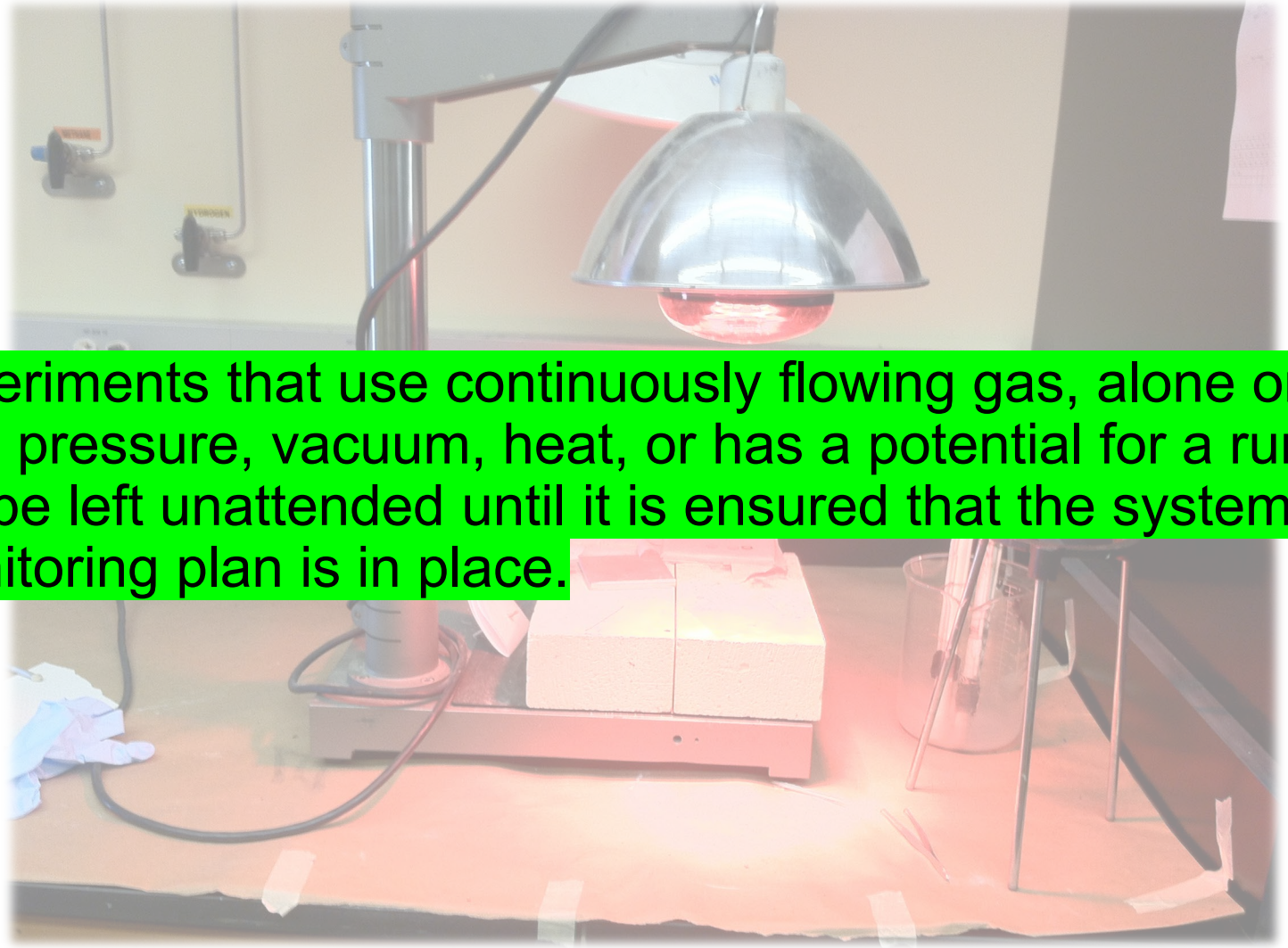
Have a plan for unattended operations

Have a plan for the unexpected

Have a plan for changing out cylinders

Follow the plans (written Standard Operating Procedure)

UNATTENDED EXPERIMENTS OR PROCESS



Experiments that use continuously flowing gas, alone or in conjunction with high pressure, vacuum, heat, or has a potential for a runaway reaction must not be left unattended until it is ensured that the system is stable and a monitoring plan is in place.

PREPARE FOR EMERGENCIES

- Prepare a written procedure to follow in the event that a fire breaks out or there's a major gas leak in the system and or personnel have been exposed to or injured by released gas. Include phone numbers of persons or office to call during emergencies. Post these procedures in the vicinity of the exit doors.

- Ensure that safety equipment including fire extinguisher, first aid kits, emergency eyewash and shower are available, visible, accessible and functional.

- Practice written emergency procedures.

POLICY

All laboratories using highly hazardous gases (toxic, corrosive, flammable, reactive, pyrophoric) must have written emergency shut-down checklist for procedures involving gases. Emergency shutdown is to be implemented ONLY WHEN PERSONAL SAFETY IS NOT COMPROMISED.

Emergency numbers for personnel who can assist and/or provide needed information during an incident involving highly hazardous gases must be liosted on the written emergency procedure and on the hazard notice at the lab entrance.

THERE IS A FIRE

1. Pull an emergency fire alarm.
2. Evacuate the building using the nearest exit stairway. Warn everyone on your way out.
3. Call 911 and provide the information asked by the dispatch personnel.
4. Proceed to the designated assembly point.

If your clothing is on fire

1. "STOP, DROP and ROLL". (If someone is on fire, instruct the person to drop to the ground and to roll back and forth Never use a fire extinguisher on a person. A damp fire-resistant fabric may be used if the fire does not involve water-reactive chemicals.)
2. Cover your face with your hands.

SOMEONE INHALED A HAZARDOUS GAS

1. Bring the person to fresh air.
2. Call 911.
    - Provide the location of the injured person
    - Provide the identity of the hazardous gas involved, *if known*
    - Describe activities that caused the incident and your initial response
    - Provide other relevant information that may help responders evaluate and stabilize the incident

THERE IS A GAS LEAK AND THE GAS ALARM WENT OFF!

1. Pull the nearest fire alarm if a building evacuation is needed.
2. Evacuate the building using the nearest exit stairway. Warn everyone on your way out.
3. Call 911 and provide the location of the gas leak and the gas involved. Describe activities that caused the incident and your initial response. Provide other relevant information that may help responders evaluate and stabilize the incident
4. Proceed to the designated assembly point.

For researchers in Horizon, consult page 13-14 of compressed gas safety

SAMPLE EMERGENCY PROCEDURES

Sample emergency procedures can be found here. Once you get to the webpage, click on “safe handling of compressed gases” to download the document and scroll down to page 13 and 14.

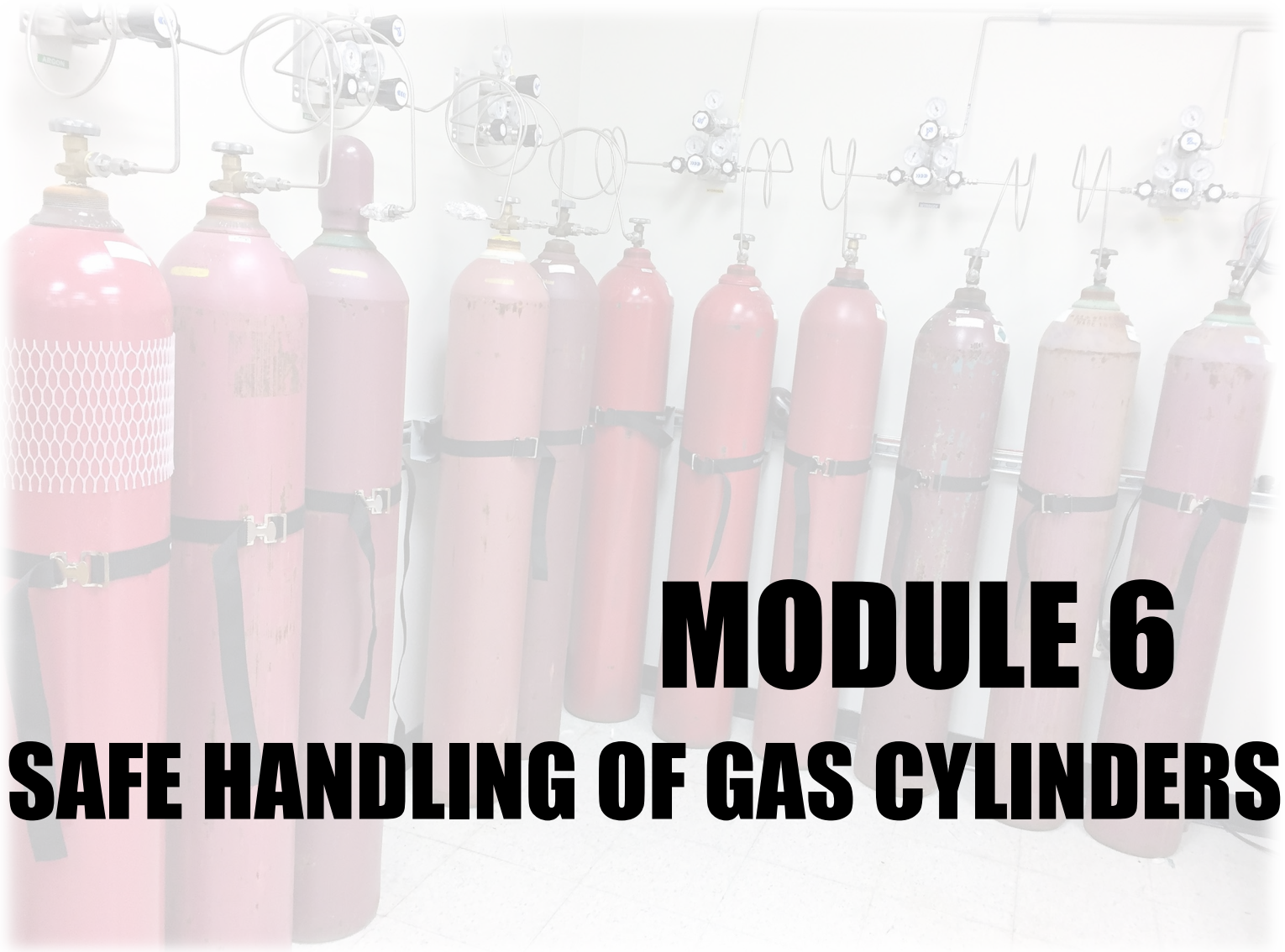
CHANGING OUT CYLINDERS

- Close the in-use cylinder valve by turning the hand wheel to the closed position. If you are unable to turn the valve, do not apply a tool or excessive force. Contact the vendor for assistance.
- Shut-off any outlet downstream of the regulator. Carefully release pressurized gas from regulator and gas lines into a fume hood or gas cabinet exhaust duct.
- Seal or purge gas lines depending on the type of gas you are using.
- Disconnect regulator from the valve CGA connection point using a fitted wrench (a non-sparking wrench is required for flammable gases). Connections for gases that are toxic, corrosive, flammable, or pyrophoric may have left-handed threads; these connections are marked with a groove inscribed around the nut. Left-hand threads loosen by turning clockwise.
- Move the empty cylinder to its designated area.
- Move and secure the replacement cylinder and connect the regulator.

CHANGING OUT CYLINDERS (CONT…)

NOTICE

- Before disconnecting the regulator, ensure that the cylinder valve is closed and the regulator is relieved of pressure. Vent residual gas through a vent line inserted into a fume hood or gas cabinet duct.
- Researchers in Horizon: Coordinate with Building Maintenance or EH&S personnel to be on standby during the change-out in case nearby gas sensors signal an alarm.
- Gas lines for corrosive gases must be purged and filled with an inert gas during cylinder change out to ensure that no air enters the gas lines – this will cause corrosion.



MODULE 6

SAFE HANDLING OF GAS CYLINDERS

6. HANDLING GAS CYLINDERS:

How should I maintain, place/locate, secure, store, transport and “dispose” of gas cylinders?

6.1. Maintain cylinders and labels in good condition

- Do not remove or alter cylinder labels.
- Add a hangtag on the cylinder that indicates whether the cylinder is full, in-use or empty.
- When cylinder is defective, unlabeled, or label has been defaced or altered, return to the vendor.
- Always position cylinders upright unless cylinder is designed by manufacturer to be used in a horizontal position.

6.2. Place cylinders in locations where they are protected

- Storage areas must be secured from access by unauthorized users.
- Store away from locations where they can be struck or objects can fall on them such as doorways, walkways and other major thoroughfares.
- Store in areas that are well ventilated, fire-resistant and dry.
- Store away from heat, flame or temperature extremes. Container temperature should not be allowed to exceed 125^{o}F.
- Store 10 ft. away from combustible and flammable materials.
- Store away from where it can be damaged by an electrical arc or can become part of an electrical circuit.
- Store away from high magnetic-field equipment.

6.2. Place cylinders in locations where they are protected (cont...)

- Store according to hazard class, with sufficient distance or separation between incompatible gases. One-hour fire rated partition or 20 ft. separation is required between flammable and oxidizing gases.
- Store pyrophoric gases only in special gas cabinets or storage areas specifically designed for this type of gas.
- Store away from exposure to salt or corrosive fumes to avoid corrosion of cylinder and the valve protection cap threads making the cap difficult to install or remove.
- Designate an area for empty cylinders separate from cylinders with contents.

6.3. Secure cylinders

- Secure to prevent cylinders from falling or being knocked over by corralling or securing them to a cart or fixed object by use of restraint. Use non-combustible strap or chain to secure a maximum of 2 cylinders per chain.
- Keep valve protective caps at all times, except when the cylinder is fitted with a regulator and connected to a system/process.
- Treat all gas cylinders (including “empty” or with residual gas) as if they are full. Secure cylinders at all times, regardless of whether they contain gas or are empty.
- Cylinders must be secured and capped at all times even when awaiting pick-up by the supplier.

6.3 a. Secure cylinders properly.

PROPER

- Cylinder mount anchored on to the wall
- A strap secures only one cylinder
- Strap is positioned on the upper 2/3 of the height of the cylinder if mounted to the wall. Can be lower if floor-mounted.

NOT PROPER

Too many cylinders chained together

Unsecured

Cylinders chained around the neck!

6.3 b. Secure against unauthorized access.

- Secure against access by unauthorized personnel by keeping the door locked when no one is present in the lab.
- If gas cylinders are inside a gas cabinet in a common area, keep the gas cabinet locked.

6.4. Transport cylinders properly.

- Do not drag, roll or slide cylinders.
- Never try to catch a cylinder from falling.
- Never lift a cylinder by its valve protection cap or by its regulator.
- Never transport a gas cylinder in a horizontal position.
- Never transport a cylinder with a pressure regulator attached.
- Ensure that the valve protection cap is secured on a cylinder for transport.
- Use an approved cylinder rolling cart that mounts the cylinder at a 45° angle and secures it with a chain or a strap.
- Small lightweight cylinders, such as lecture-size cylinders may be designed without a valve protection cap. Do not carry these cylinders by hand; use a rolling cart and secure the cylinder on the cart. Dropping these cylinders and damaging the valve can cause the valve stem to expel and cause serious injury.

6.4. Transport cylinders properly (continued).

NOTE

If valve protection cap is not secured on the cylinder and the cylinder is dropped, the valve can get damaged or sheared off, rapidly releasing pressure and propelling the cylinder like a rocket.

POLICY

- **Gas cylinders may not be transported by cart across any road with vehicular traffic.**
- **Gas cylinders may not be transported using a private vehicle.**
- **Only gas vendor and authorized UofSC personnel with hazardous material transport permit may transport cylinders using an official UofSC vehicle.**

South Carolina

6.5. Return to ~~sender~~ vendor when cylinders are:

- unlabeled or label has been altered or defaced
- damaged
- corroded
- leaking
- hydrostatic testing has expired (every 5 or 10 years depending on the type of cylinder; if the last stamp date has a star next to it, the test is due 10 years after this date; Slide #13)

NOTE

- All unwanted, returnable gas cylinders, empty or with contents must be returned to the gas vendor. Ensure that cylinders for pick-up by the vendor have the valves closed and the valve protection cap secured in place.
- Unknown and/or unused, non-returnable gas cylinders, with contents or empty, of any size (including lecture bottles) are to be discarded as hazardous waste through Environmental Health and Safety. Please contact the Hazardous Waste Manager at (803) 777-5269 or (803) 777-1935.

MODULE 7

HIGLY HAZARDOUS GASES

7. HANDLING HIGHLY HAZARDOUS GASES

Gases that are oxidizers, flammable, corrosive, toxic/highly toxic, pyrophoric, and unstable reactive have physical and health hazards related to the properties of the substance themselves in addition to being highly pressurized in a cylinder. These gases are highly hazardous. There are additional guidelines that must be followed to enable their safe use in the laboratory.

HIGHLY HAZARDOUS GASES

Hazard Category (NFPA Class 3, 4) or specific gas	Critical Engineering Controls and Precautions
Flammable[1]	Separated from oxidizers by a gas cabinet or distance of 20 ft; use non-sparking fitted wrench when connecting or disconnecting regulators and fittings.
Acetylene[1]	Separated from oxidizers by a gas cabinet or distance of 20 ft; use non-sparking fitted wrench during installation; use at pressures below 15 PSI only. (Acetylene can become unstable and violently decompose at pressures above 15 PSI).
Oxygen[1]	Separated from flammables by a gas cabinet or distance of 20 ft; make sure valves, fittings, connections, tubings, *etc*. are free of grease and other organic material contamination.
Toxic and Highly Toxic[1,2]	Gas-tight valve outlet caps or plugs when stored.
Pyrophoric[1,2]	Gas-tight valve outlet caps or plugs when stored; use non-sparking fitted wrench during installation.
Unstable reactive[1,2]	Gas-tight valve outlet caps or plugs when stored; use non-sparking fitted wrench during installation.

[1]Allowed quantities are based on reasonable amount needed in experiment according to hazard and risk assessment.
[2]Housed in a gas cabinet; gas-specific detector is required. Detection system may or may not need to be connected to a fire alarm panel.

SUMMARY

- **Compressed gases are hazardous**.
  - Gas cylinders are heavy.
  - Gases are highly pressurized within the cylinder.
  - Certain gases are highly toxic, toxic, corrosive, and many are asphyxiants.
  - Many gases are also oxidizers, flammable, unstable reactive and/or pyrophoric.
- **Prior to working with compressed gases, make sure that you have**:
  - completed all 7 modules of this training,
  - asked questions if any of the information is unclear,
  - read and understood your written standard operating procedures for the gas that you will use,
  - signed the written SOP,
  - reviewed the information on the compressed gas safety document.

QUESTIONS?

- Call Jocelyn Locke (803) 777-7650 or email jlocke@mailbox.sc.edu
- Take the quiz here.
- Print a copy of your score to show your supervisor.

Thank you!