Chapter 7
Compressed Gas Cylinders

A. References

1. WAC 296-24 Part K Compressed Gas and Compressed Gas Equipment
2. WAC 296-24 Part E Hazardous Materials, Flammable and Combustible Liquids, Spray Finishing
3. Compressed Gas Association "CGA P-1: Safe Handling of Compressed Gases"
4. International Fire Code (IFC) Section 3004: Storage of Compressed Gases
5. IFC Section 3005: Use and Handling of Compressed Gases
6. Washington Department of Health Publication "DOH 331-364: How to Handle Chlorine Gas Safely" May 2010.
7. SPPM 2.80 Compressed Gas Cylinders

B. Overview

Compressed gas hazards include flammability (fire and explosions), corrosivity, toxicity, and oxygen displacement, as well as the physical hazards associated with high pressure systems. Precautions are necessary when storing, using, and/or handling compressed gases to control these hazards.

WSU personnel working with or around compressed gas, must be knowledgeable of, and adhere to, the requirements in this chapter and SPPM 2.80.

C. Responsibilities

DEPARTMENT CHAIR/DIRECTOR

The department chair or director is responsible for:

- Ensuring that policy SPPM 2.80 is implemented.
- Reviewing all incident reports.
- Ensuring that appropriate corrections are made.
- Communicating incidents and corrective actions to affected personnel.

PRINCIPAL INVESTIGATOR, DESIGNEE, AND/OR SUPERVISOR

The principal investigator (PI) or designee and/or the supervisor is responsible for ensuring that:

- Compressed gas cylinders are inspected in accordance with this policy's cylinder inspection requirements, referencing state and federal requirements. (See Cylinder Inspections; WAC 296-24-29501; WAC 296-24-92005; and NIOSH Publication Number 2004-101.)
- The PI, designee, and/or supervisor must immediately return to the supplier any damaged cylinders and cylinders which have passed the required dates for manufacturer's inspection (every five years).

- Compressed gas regulators, valves, and piping/delivery systems meet Compressed Gas Association (CGA), American National Standards Institute (ANSI), and this policy's requirements.
- Personnel under their supervision (employees; paid and unpaid students) receive necessary training and that training is documented.
  Training must include general safety guidelines on working with, handling, and transporting compressed gases and compressed gas cylinders and gas specific (e.g., flammable, toxic) hazards.
- Employees use necessary personal protective equipment (PPE) when working with or around compressed gases. (See WAC 296-800-16005.) Minimum PPE includes full length pants and closed-toe shoes. (See also SPPM 2.60.)
- The following storage requirements are met:
  - Gas cylinders are stored appropriately,
  - International Fire Code (IFC)-allowable storage quantities are not exceeded, and
  - Required gas detection provisions (e.g., detection of toxic or flammable gas) are met.
- Compressed gas cylinders are transported as identified under Gas Cylinder Transport.
  Gas cylinders must be transported with the valve up, the valve protection cap fully threaded in place, and secured in a fixture designed for gas cylinder transport.

EMPLOYEE
All employees must:

- Participate in required training before using compressed gases.
- Use appropriate PPE as required by the department and/or supervisor.
- Inspect gas cylinders in accordance with this policy's cylinder inspections requirements, referencing state and federal requirements. (See Cylinder Inspections; WAC 296-24-29501; WAC 296-24-92005; and NIOSH Publication Number 2004-101.)
- Confirm the identity of the gas before using by reading the label or other markings on the cylinder. If cylinder contents cannot be identified through the label or markings, the employee must return cylinder to the supplier without using.
- Store gas cylinders in accordance with the requirements in this chapter and SPPM 2.80.
- Transport compressed gas cylinders in accordance with the requirements in this chapter and SPPM 2.80.
- Secure gas supplies and close cylinder valves when not in use.

The employee must **not**:

- Use gas cylinders, regulators, fitting, or tubing if damaged. The employee must notify their supervisor of damaged gas cylinders and arrange for immediate return to the supplier.
- Modify, tamper with, paint, obstruct, remove or repair any part of the cylinder, including the pressure relief device and the container valve or the valve protection device. NOTE: It is illegal to remove or to change the prescribed numbers or marks stamped into cylinders.

D. Training

WSU personnel working with or around compressed gases must be trained at the time of hire in general compressed gas and compressed gas cylinder safety principles. The safety principles include site-specific safety procedures and gas specific hazards. Safety training must be documented.

Training requires that participants demonstrate to their immediate supervisor or PI an understanding of the topic and proficiency using the equipment. Retraining is required when:

- Changes are made in the workplace, such as new processes and equipment, which render previous training obsolete;
- Equipment changes are made that render the previous training obsolete; and/or
- An employee exhibits inadequate knowledge, skill, and understanding, or nonconforming use of the equipment.

E. Gas Cylinder Use

The following requirements apply to the use of compressed gas cylinders. See Acetylene for additional requirements for using acetylene in compressed gas cylinders.

- Always follow the manufacturer's recommendations for setting up and operating equipment.
- **IMPORTANT**: Wear appropriate PPE when working with compressed gases. Minimum PPE includes full length pants and closed-toe shoes. (See also SPPM 2.60.)
- Cylinders must be secured for use as identified in Securing Cylinders under Gas Cylinder Storage.

Cylinder Inspections

Cylinder inspection requirements include:

- Perform regular visual inspections of compressed gas cylinders for leaks, cracks, and deformities.
- Always ensure that all connections are leak tight. Each time connections are loosened and retightened, each connection should be checked. Pressurize the gas delivery system and use one of the following to check the connections:

  - Soap and water solution (oil free soap);
  - Liquid gas leak detector (e.g., Snoop®); or
  - Appropriate gas detector.

    Do not use flame to check connections.
- If a cylinder is ever thought to be defective, it should be removed from service and returned to the supplier for replacement.

Repairs
Repair work on cylinders, cylinder valves, gauges, and regulators must be performed by qualified personnel.

Pressure Regulating Devices
Pressure regulation device requirements include:

- All compressed gases must be used through a pressure regulating device on the cylinder or manifold.
- Always use a regulator to reduce gas cylinder pressure to the operating pressures recommended by the equipment manufacturer.
- All piping and equipment must meet CGA standards.

Regulator Inspections
Regulator inspection requirements include:

- Perform regular visual inspections of pressure regulating devices.
- Do not use a pressure regulator if gauges or relief valves:
  - Are damaged or missing; or
  - Have been modified without documenting conformance with the standards of the Compressed Gas Association (CGA).

Attaching a Regulator

Before attaching a regulator to a gas cylinder, fully release the regulator adjusting screw (back off in a counter-clockwise direction) so that there can be no flow through the regulator when the cylinder valve is initially opened.

Laboratory analytical equipment only, such as gas chromatographs or flame ionization detectors, are exempt from this requirement. NOTE: The exemption does not apply to laboratory process or batch equipment.

Valves
Requirements when working with cylinder valves:

- Never stand in the flight path of a regulator handle, gauge, or relief valve when opening a cylinder valve.

- Always open the cylinder valve slowly, controlling the rate gas pressure increases in the regulator (particularly in an oxygen cylinder). Opening the cylinder valve too quickly causes heat due to gas recompression. The resulting heat may ignite combustible materials.
- Never use force when opening or closing valves.
- When in use, cylinder valves in the fully open position may become stuck. To prevent this, open the valve completely, then turn the handwheel or cylinder valve key back half a turn.
  NOTE: Acetylene cylinders should never be open more than one and one-half turns, preferably only three-quarters of a turn.
- Valves must be closed when gas is not in use.

Removing a Regulator

Requirements for removing a regulator include:

- Before removing a regulator, close the main cylinder valve and slowly release remaining pressure from the low-pressure side of the regulator.
- Removing regulator fittings under pressure may result in serious personal injury, as fittings may be ejected at high velocity and gas bubbles can be embedded under the skin.

Hoses

Requirements when working with cylinder hoses:

- Always remove defective hoses from service.
- Never repair hoses.
- Gas hoses must meet CGA specifications.

Use Restrictions

Cylinder use restriction requirements:

- Never use cylinder equipment for gases with different chemical properties other than those for which the equipment was designed by the manufacturer, unless the manufacturer or supplier provides information indicating that such use can be done safely. Cylinder equipment includes regulators, gauges, hoses, and other appliances.
- Never attempt to adapt or use a fuel gas or inert gas regulator on an oxygen cylinder. Oxygen regulators must be free from combustible parts, grease, or oil.
- Never force connections that do not fit. Threads on regulator connections or other auxiliary equipment must be the same as those on the cylinder valve outlet.
- Never tamper with the safety devices on cylinders (e.g., fuse plugs, safety discs).
- Do not permit electric arcs, torch flames, or sparks to strike the cylinder.
- Never use wrenches or tools except those provided or approved by the gas manufacturer to open gas cylinder valves.

- Never use cylinders as rollers to move other material, or as supports, or for any purpose other than to contain the contents as received.
- Do not let cylinders bump into each other or fall.
- Do not place cylinders where they may become part of an electric circuit or might be burned by electric welding arc.
- Do not use cylinders as a ground during electric welding.

Securing Cylinders

Requirements when securing cylinders:

- Cylinders must be secured as identified under Gas Cylinder Storage. NOTE: More than one cylinder restraint should be used in seismically active areas. Metal chains must be used at WSU Tri-Cities.
- Cylinders must be used under the regulations, standards, and conditions identified under Gas Cylinder Storage. NOTE: Oxygen and fuel gas cylinders in use (regulators attached) are not subject to fire code separation distances or barriers such as the fuel gas and oxygen cylinder supplying a cutting torch. For oxidizing and fuel gas cylinders not in use, separation distances or barriers apply.

Cleaning

Cylinder cleaning requirements:

- Keep cylinders, valves, piping, and fittings clean.
- Never apply sealants (liquid or tape form) or lubricants to any cylinder valves or connection fittings. The threads are not the sealing surface, therefore, leaks at CGA fittings indicate a damaged fitting on the regulator or tank.
- Never let oil or grease contact the cylinder or its valve and fittings. This is especially important for cylinders used with oxygen and other oxidizing gases. Such cylinders often require fittings specifically cleaned and bagged for oxygen use.

F. Use of Cylinders with Specific Chemicals

The following additional requirements apply to the use of fuel or oxidizing gas, hydrogen, or acetylene in compressed gas cylinders.

Fuel or Oxidizing Gas

Requirements when working with fuel or oxidizing gas:

- When mixing fuel gas and oxygen to support combustion (e.g. cutting torch), install flashback arrestors on both the fuel gas and oxygen cylinder regulators, or as close to the point of mixing as possible.
- Check valves may be used when fuel or oxidizing gas are not mixed in-line and potential for back pressure within the distribution system is eliminated.

Hydrogen
Ground hydrogen cylinders when in use.

Acetylene

- Never use acetylene in excess of 15 psi pressure. Higher acetylene pressures are dangerous.
- Requirements when working with acetylene cylinder valves:
  - Acetylene cylinders should never be open more than one and one-half turns, preferably only three-quarters of a turn.
  - If a cylinder is not fitted with a handwheel valve control, any manufacturer/supplier-provided tools required for opening the valve must be placed on the cylinder (e.g., hung from the cylinder) while the cylinder is in service. This ensures that the valve may be shut quickly in an emergency. On manifolds, one wrench for each manifold is sufficient.
- All cylinders, particularly acetylene, must be restrained securely in an upright position to prevent accidents.
- Using an acetylene cylinder in a nonvertical position allows the discharge of acetone through the regulator. Acetone discharge may potentially clog passages and create a fire hazard. It may also cause voids in the porous material inside the cylinder, which can lead to acetylene explosions.
- Never use copper tubing or other copper equipment with acetylene.
- Cylinders with arc or torch burns must be removed from service immediately.

G. Gas Cylinder Storage

The following requirements apply to the storage of compressed gas cylinders.

Regulations and Standards
Cylinders must be stored in accordance with state regulations (WAC 296-24-29501 and WAC 296-24-920), and IFC and CGA standards.

Signage
Classes of hazardous gases used must be posted near the entrance to the laboratory or cylinder storage area.
NOTE: This signage requirement does not apply to cutting torch use in the field or fuel gas supplying of motorized equipment, unless otherwise required by local, state, or federal transportation regulations.
For laboratories, hazardous gas signage is created through the Laboratory Signage Program. (See SPPM 4.33.)
For nonlaboratory facilities, hazardous gas signage is created using National Fire Protection Association (NFPA) signage or other gas specific signage (e.g., “Danger–Chlorine Gas”).

Securing Cylinders
Requirements for securing cylinders:

- Cylinders must always be secured in an upright position on a firm, level floor to protect against falling or rolling.
- When bench clamps are used to secure gas cylinders, the clamps must be installed in accordance with manufacturers' recommendations (e.g., anchored behind a bench counter lip).
- Cylinders (full and empty) must be anchored at all times to a wall or bench clamp or secured within cylinder racks, stands, or a special truck (e.g., cutting/brazing torch). An appropriate restraint device (strap or chain) must always be used. The restraint device must be located in the upper third and the lower third the height to the shoulder of the cylinder. NOTE: Steel chains must be used at WSU Tri-Cities.

Valves

Valves must be closed with valve protection caps secured when transporting cylinders and whenever regulators are not on the cylinders. Caps should be hand tight and not forced or over tightened.

Storage Conditions

Requirements for cylinder storage:

- Storage areas should be dry and well ventilated.
- Cylinders must be stored away from excessive heat sources, such as stoves, furnaces, radiators, electric welding tools, direct sunlight, and the presence of open flames. Cylinders should not be subjected to a temperature above 125 degrees Fahrenheit (52 degrees Celsius).
- Cylinders stored outside must be protected against severe weather, tampering, combustible waste, and the ground beneath to prevent rusting. Cylinders must be stored at least 20 feet from combustible and incompatible materials, such as oil, gasoline, or waste, and vegetation.
- Cylinders should not be exposed to:
  - Excessive dampness,
  - Salt, or
  - Corrosive chemicals or fumes.
- If snow or ice accumulate on a cylinder, thaw at room temperature, or with water at a temperature not exceeding 125 degrees Fahrenheit (52 degrees Celsius).
- Cylinders must not be subjected to artificially created low temperatures without the approval of the supplier. Many steels undergo decreased ductility at low temperatures.
- Cylinders must be protected from objects that would cut, damage or otherwise abrade the metal surface.
- Store cylinders away from heavy traffic and emergency exits.

- Do not store cylinders in hallways.
- Cylinders must not be stored near elevators or gangways, or in locations where heavy moving objects may strike or fall on them.

Chemical Hazards

Chemical hazard requirements:

- Cylinders must be grouped by hazard class and the groups subsequently arranged by type of gas contained. Incompatible gases, such as flammable (e.g., acetylene) and oxidizing (e.g., oxygen), unless in-use (regulators attached), must be separated by:
  - A minimum of 20 feet, or
  - A noncombustible barrier at least five feet high having a fire resistance rating of at least one-half hour.
- Toxic gas monitors must be installed in toxic gas storage areas and set to alarm if a release is detected. Exhausted enclosures may be required by fire code.
- When toxic gases are used, the unit must develop procedures for purging toxic gas to support removing the regulator to change cylinders.
- Corrosive gases must be managed with the same precautions as toxic gases. Gas distribution systems must be gas compatible. (See also Compressed Gas Distribution Systems.)
- Flammable and oxidizing gases may require additional monitors and are subject to storage limitations. Review the appropriate WAC, IFC, or CGA codes specific to the gas.
- Never store liquid or gas chlorine cylinders with ammonia cylinders.

Stock Rotation

Stock rotation requirements:

- Empty and full cylinders must be stored separately, with the storage layout designed so that cylinders made up of old stock can be removed first.
- Empty cylinders must be marked accordingly using either:
  - The attached tear-off wire tag label;
  - Another suitable sign or tag; or
  - By writing “Empty” or “MT” in chalk on the cylinder.
- For laboratories, arrangements should be made for empty cylinders to be picked up by the supplier as soon as possible.
- Never try to refill a compressed gas cylinder.
- Rotate stock of full cylinders, and use cylinders on a “first in, first out” basis.
- Typically, gas cylinders should not be stored longer than one year without use.

Security

Storage, use, and handling areas must be secured against unauthorized entry or access to unauthorized personnel.

H. Gas Cylinder Transport

The following requirements apply to the transport of compressed gas cylinders.

Prior to Transport

Prior to transporting compressed gas cylinders:

- Connected equipment (e.g., regulators) must be removed;
- Valves must be closed; and
- Removable valve protection caps must be secured at all times.

PPE

Wear suitable PPE when transporting cylinders. Leather gloves and safety footwear, for example, can provide some protection against falling/slipping cylinders crushing hands or feet during moving.

The supervisor or PI must identify appropriate PPE for moving gas cylinders. At minimum, full length pants and closed-toe shoes are required.

Equipment

Equipment requirements for transporting gas cylinders:

- Use a suitable hand truck or cart in good condition designed for cylinder movement with cylinders firmly secured.
- Use ramps when available. Avoid lifting/lowering cylinders on steps whenever possible.
- Cradles must be used for hoisting.
- Lifting magnets must not be used.
- Ropes, chains or slings are not authorized for lifting a cylinder unless the cylinder includes provisions for appropriate lifting attachments, such as lugs.
- Use a freight elevator for vertical transportation when possible. If a freight elevator is unavailable, do not use an elevator with passengers or people not involved in toxic or corrosive gas cylinder transport.

Movement Restrictions

Restrictions for moving gas cylinders:

- When moving a gas cylinder a short distance, avoid rolling it on the bottom edge (edge-rolling), if possible, unless the cylinder is on a smooth, level, firm surface.
- Sliding, dragging or rolling a cylinder on its side is not permitted, as it causes excessive wear and may weaken cylinder walls.
- Avoid dropping and striking cylinders together. Do not drop cylinders as a method of transfer.

- Do not lift cylinders by the cap, valves, or valve hand wheels.
- Do not bear-hug cylinders to effect a lift.
- Do not attempt to catch or restrain a falling cylinder.
- Do not attempt to handle cylinders if fatigued, physically compromised, or under the adverse influence of medication.

Placement for Transport
Requirements for placement of cylinders while being transported:

- Fuel gas and liquefied fuels, excluding liquefied propane or natural gas cylinders designed for horizontal use, must be stored and shipped valve end up.
- Cylinders must be upright when transported in powered vehicles.

Valve Protection
Valve protection requirements while transporting cylinders:

- All cylinders with a water weight of over 30 lbs. must have valve protection caps or other protection.
- Valve protection caps must be on cylinders at all times while transporting, excluding moving welding gas about a localized work area on a specialized carrier or dolly.

I. Compressed Gas Distribution Systems

The following requirements apply to compressed gas distribution systems.

Equipment
Gas cylinder distribution systems, e.g., valves, regulators and/or tubing, must be compatible with the gas conveyed by the system.

Tubing
Tubing requirements for compressed gas distribution systems:

- Flexible tubing is preferable for connections that are frequently detached and reconnected, e.g., connections between the:
  - Cylinder and distribution system;
  - Regulator and distribution system; and
  - Distribution system and equipment.

Disconnecting and reconnecting rigid tubing can cause premature wear. Flexible stainless steel tubing options are available.

- Gas distribution tubing passing through fire rated walls or enclosures must be sealed to maintain the integrity of the fire rating, e.g., fire caulk.
- Plastic or rubber tubing must be located away from heat sources and electrical cords to prevent damage.
- Gas distribution tubing must be located sufficiently distant from electrical equipment such that arcing is not feasible.

Valves
Valve requirements for compressed gas distribution systems:

- Gas cylinder valves must be closed when gas is not in use.
- Do not use grease or oil on valves or other connections carrying oxidizing gas.
- In some cases, a direct ventilation system with appropriate pressure relief valves may be required for a gas distribution system. Review the appropriate WAC, CGA, or NFPA standards specific to the gas being used.

Inspections
Inspection requirements for compressed gas distribution systems:

- Gas cylinder distribution systems supplying flammable, corrosive, or toxic gas must be inspected regularly for leaks. Leaks are most frequently detected at connections/fittings.
  Leak tests may be performed by:
  - Using a liquid leak detector (e.g., Snoop®) or soapy water;
  - Using a gas detector; or
  - Pressurizing the delivery system and evaluating pressure within the system over time (tightness testing).

J. Emergencies

The following requirements apply to compressed gas emergencies.

Preparations
Emergency preparation requirements:

- Emergency equipment, such as emergency eyewash, emergency shower, and fire extinguisher, must be available.
- Emergency procedures must be developed and implemented for emergency situations. Posting emergency procedures is recommended.
- A safety data sheet (SDS) must be readily available for each type of gas.

Valve Caution
If a gas cylinder is leaking, do not over-tighten the valve in an attempt to stop the leak.

Evacuation
Consider room and building evacuation, as necessary. If the hazard warrants building evacuation:

1. Pull the fire alarm,
2. Leave the building, and
3. Call 911 to inform first responders of the conditions warranting the alarm.

Response Based on Gas Type
Take the following actions as appropriate, providing it is safe to do so, based upon personal training and the hazards present.

Highly Toxic Gases
If a leak of highly toxic gases (e.g., fluorine, nitric oxide, phosphine, hydrogen cyanide, arsine) is suspected, evacuate the area and call 911 immediately.
Highly toxic gases should only be used inside exhausted enclosures, e.g., a lecture bottle in a fume hood or a cylinder stored inside a gas cylinder cabinet.

Toxic or Corrosive Gases
If a leak of toxic or corrosive gases is suspected:

- If possible, allow the cylinder to exhaust into the building's hazardous exhaust (not general building exhaust), e.g., fume hood or snorkel;
- Evacuate the room or building (see Evacuation);
- Post signs at all entrances to the affected area; and
- Contact the campus Environmental Health and Safety (EH&S).

Flammable, Oxidizing or Inert Gases
If a leak of flammable, oxidizing, or inert gases is suspected:

- Eliminate potential ignition sources (e.g., shutdown electrical equipment; extinguish flames) in the event of a flammable or oxidizing gas leak, if possible and safe to do so.
- If possible and if leak involves inert gases only, allow the cylinder to exhaust into the building's hazardous exhaust (not general building exhaust), e.g., fume hood or snorkel.
- Post signs at all entrances to the affected area; and
- Contact the campus Environmental Health and Safety (EH&S)

Hydrogen Gas Alert
NOTE: Hydrogen gas' explosive limits range from 4 percent to 77 percent with an ignition energy of just 0.02 millijoules. Hydrogen can spontaneously combust if released at high pressures and the resulting fires may be invisible.

K. Adherence to Gas Cylinder Safety Policy

Failure to comply with gas cylinder safety policies and procedures is to be considered serious and result in timely corrective or disciplinary action judged to be appropriate for the specific circumstances at hand. Progressive corrective/disciplinary action is appropriate for addressing non-compliance, recognizing that more serious offenses do not necessarily require that intermediate steps be taken first.

Questions concerning appropriate corrective or disciplinary action should be addressed to the appropriate director/manager or Human Resource Services.