Stony Brook University

Environmental Health & Safety Policy and Procedure

Subject: Compressed Gas and Cryogenic Fluid Handling, Storage and Disposal	**Date**: May 2021
EH&S Program: Laboratory Safety	**Next Review**: May 2024
Scope: University Wide	**Original**: 1993

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Policy:

Where compressed gases are stored, handled, or used, they shall be managed in a manner which prevents, or reduces, the physical and/or chemical hazards they present.

Definitions:

Asphyxiant gas: A gas, usually inert, that may cause suffocation by displacing the oxygen in the air necessary to sustain life.

Compressed gas: A gas or mixture of gases having an absolute pressure exceeding 40 psi at 70 °F (21.1 °C); or, a gas or mixture of gases having an absolute pressure exceeding 104 psi at 130 °F (54.4 °C) regardless of the pressure at 70 °F; or, a liquid having a vapor pressure exceeding 40 psi at 100 ° F (37.8 ° C) as determined by ASTM D-323-72.

Corrosive gas: A gas that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the point of contact. Examples: ammonia, chlorine, sulfur dioxide

Cryogenic fluid: A refrigerated liquefied gas having a boiling point colder than -90 °C (130 °F) at 14.7 psi absolute. Examples of common cryogens: argon, helium, hydrogen, nitrogen, oxygen, methane.

- Flammable cryogenic fluid: is flammable in its vapor state
- Oxidizing cryogenic fluids: have oxidizing properties which increase the burning rate of normal combustibles

Flammable gas: A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or, a gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit. Examples: hydrogen, carbon monoxide, acetylene

Highly Acute Toxic gases: are defined based on lethal concentration (LC50) in air where 50% of a sample population of albino rats die after 1-hour exposure. These may be fatal or cause damage to target organs because of a single exposure or exposures of short duration. Examples: chlorine, hydrogen sulfide, methyl mercaptan, phosphine.

They are further classified depending upon the LC50 levels:

- Toxic gases: have a median LC50 in air of more than 200 ppm, but nor more than 2000 ppm, by volume of gas. Classified as GHS Category 2 for Acute toxicity.
- Highly Toxic Gases: have a median LC50 in air of 200 ppm or less. Classified as GHS Category 1 for Acute Toxicity.

Oxidizing gas: A gas that is nonflammable but can support and vigorously accelerate combustion in the presence of an ignition source and a fuel. Examples: oxygen (concentrations above 23-25%) nitrogen oxides, halogen gases such as chlorine and fluorine.

Pressure Regulators: reduce a high pressure to a desirable lower pressure and maintain the delivery pressure and flow level for the required operating conditions.

Pyrophoric: a chemical with an auto-ignition temperature in air, at or below a temperature of 130°F (54°C). Examples: silane, diborane, phosphine

Procedures:

A. Responsibility

1. **Principal Investigators/ Supervisors/Lab Directors/Facility Manager must:**
   a. Ensure that all laboratory members have completed the required safety training prior to handling compressed gas and cryogenic fluids.
   b. Provide training to laboratory personnel on the storage and handling of compressed gases and cryogenic fluids in the laboratory.

c. Implement Standard Operating Procedures (SOPs) about storage, handling and transport of compressed gas cylinders especially flammable, toxic, oxidizing, pyrophoric and corrosive gases.

2. **Laboratory Staff/ Employees/ Students:**
   a. Compressed gas cylinders must be handled only by experienced and properly trained personnel.
   b. Users must complete the following training:
      - ELS002: Laboratory Chemical Safety
      - ENV001: Hazardous Waste prior to working with compressed gases.

   For classroom training or specific training contact Environmental Health and Safety (EH&S).
   c. The user responsible for the cylinder and for its installation should check the identity of the gas before use. The cylinder should be returned to the vendor if,
      - the cylinder content is not identified,
      - the hydrostatic test date is past due, or
      - the cylinder is in any way damaged

   d. The user shall not modify, tamper with, paint, deface, obstruct, remove or repair any part of the cylinder, including the pressure relief device and the container valve or the valve protection device.
   e. The user is responsible for:
      - the proper disposal of the cylinder when it is empty or no longer needed.
      - maintaining an inventory of all gas cylinders used and stored in their area.

3. Environmental Health and Safety (EH&S)
   a. Develop and maintain this policy.
   b. Provide guidance and support to areas where compressed gases and cryogenic fluids are used.

B. General Safety Procedures

1. Identification
   a. Cylinders must be clearly labeled with name and concentration of the contents, hazard classifications, safety precautions, manufacturers/suppliers name.
   b. Do not accept a cylinder without a proper label.
   c. Do not depend on the manufacturer's color code. They may vary across companies. Check the official label on the cylinder, not the color of the cap.
   d. Do not accept damaged/corroded/ unlabeled cylinders.

e. Place the cylinder appropriately so that the label can be easily read and visible from any direction. In case this is not possible, label the cylinder with an additional sign to indicate the type of gas and the associated hazard.
f. Always consult the gas supplier's Safety Data Sheet (SDS) for specific information related hazards, storage, handling, disposal.

2. Storage

a. Cylinders must be stored in a well-ventilated area and should not be exposed to or stored near:
   - corrosive chemicals, fumes,
   - extreme temperatures (above 51 ° C (125 ° F.) or near radiators or other sources of heat)
   - open flame or ignition sources
   - combustible materials
b. All cylinders must be stored in an upright position, unless indicated by the manufacturer/ safety data sheet.
c. Secure cylinders with a strap, chain, bracket or other approved restraint, holding the cylinder between waist and shoulder, to a fixed object (wall or bench).
d. Cylinders are to be protected with a valve cap when not in use (empty or full).
e. Do not store cylinders with pressure on the regulator.
f. Store incompatible classes of gas cylinders separately.
g. Segregate empty cylinders from full cylinders, with empty cylinders marked with the word "EMPTY" or "MT".
h. Do not store cylinders:
   - next to doors, in corridors, stairwells, near elevators, high traffic areas or where they may be obstructing an emergency exit to avoid cylinders from being knocked over and causing injuries and/or damage
   - Unventilated areas, confined spaces, cold rooms to avoid accumulation of gas in a storage location due to leaks leading to oxygen deficiency

3. Handling & Use

a. Ensure access to cylinder valve is always unobstructed.
b. Open cylinder valves slowly, and only when a proper regulator is firmly in place and the attachment has been shown to be leak proof by an appropriate test.
c. Do not force a cap or regulator. The cap should only be hand tight.
d. Do not transfer gases from one vessel to another (except dry ice and cryogenic gases).
e. Do not refill compressed gas cylinders.
f. Do not use or allow contact with oil or grease on cylinders or their valves.

g. Never use a cylinder without a regulator.
h. Never use a leaking, corroded or damaged cylinder. Remove the cylinder from service and return to supplier.
i. Do not use Teflon tape on cylinder or tube fitting connections, which have metal to metal face seals or gasket seals.
j. Never leave the cylinder valve open when the equipment is not in use.
k. Never use a screw driver to pry off a stuck cap or pliers to open a cylinder valve.
l. In the case of Toxic gases;
   - If the cylinder is being opened outside, the worker should stay upwind of the cylinder with the valve pointed downwind, away from personnel, and warn those working nearby in case of a possible leak,
   - If the cylinder is opened inside, use it in the chemical fume hood or specially designed cabinet.
   - Install a differential pressure switch/monitor with an audible alarm in the chemical fume hood for use with toxic gases. Refer to section C.4.
m. Do not empty gas cylinders to a pressure lower than 25 psi to prevent suction and backflow which can cause contamination of residual contents with air if valve is left open.

4. Pressure Regulators

a. Keep them free of oil or grease especially for oxidant gases.
b. Compressed gas association (CGA) stampings on the regulator indicate the appropriate gas for which the regulator is designed.
c. Never tamper with or adapt regulators for use with gases for which they are not designed.
d. Special regulators made of corrosion resistant materials are available for use with gases such as ammonia, hydrogen sulfide, boron trifluoride, chlorine, hydrogen chloride, sulfur dioxide.
e. Avoid using Teflon tape or any such materials on threads unless indicated by the vendor/ manufacturer.
f. All regulators should be equipped with pressure relief devices.
g. Cylinder, regulators, connections and hoses should be checked regularly for leaks.

5. Gas Piping and Tubing

a. Piping and tubing systems must be in accordance with OSHA, NFPA standards and building code
b. Do not use:
   - Copper piping for acetylene

- Cast iron piping for chlorine
- Plastic piping for high pressure systems
- Conceal distribution lines

c. For permanent piping systems, please contact Campus Planning and Design (Main Campus), Plant Operations (Health Science Center).
d. All gas lines/tubing leading from a compressed gas should be labeled to identify the gas and the equipment/area is it being used for.

6. Transport

a. The protective cap must be in place.
b. Avoid dropping and striking cylinders together. The cylinder should not be lifted by the cap.
c. Use a cradle for hoisting, never a lifting magnet or sling.
d. Use a suitable hand truck with the cylinder firmly secured. Avoid dragging, sliding or rolling cylinders.
e. Cylinders must be secured in a positive fashion with straps or chains while being transported and when in motor vehicles.
f. Use the Freight Elevator when possible. If there is no Freight Elevator, do not use an elevator with people in it and do not allow other people to enter the elevator when transporting cylinders. When transporting asphyxiant gas in elevators, send the cylinder up by itself and then follow in another elevator or stairs. This can only be done if the elevator can be made to not stop at any other floors before the cylinder is removed.

7. Disposal

a. Close and tighten valves and replace safety caps on cylinders.
b. Contact supplier/vendor to obtain guidelines for the shipment of cylinders to be returned.
c. Identify the gas that was in the container. Valves should be removed from empty nontoxic gas cylinders before disposal.
d. Contact the Department of Environmental Health and Safety for removal of cylinders that cannot be returned to the supplier/vendor or for disposal of orphaned cylinders.
e. Cylinders of hydrogen fluoride and hydrogen bromide should be returned to the supplier within two (2) years of the shipping date. Cylinders of corrosive or unstable gases should be returned to the supplier when the expiration date of the maximum recommended retention period has been reached. If no maximum recommended retention time is provided by the supplier, a 36-month (3 year) time limit should be used.

C. Special Handling

1. **Cryogenic Liquids**: due to their low temperatures are stored at low pressures in specially constructed, multi walled, vacuum insulated containers. Examples include: oxygen, nitrogen, argon, neon, hydrogen, helium. Potential hazards that accompany these products are:

   - Extreme cold can cause frostbite on contact, and can also cause embrittlement of carbon steel, plastics and rubber;
   - Container or piping failure resulting from overpressure
   - Asphyxiation due to displacement of oxygen
     - Only persons trained, qualified and using a self-contained breathing apparatus (SCBA) with adequate back-up should respond to an inert gas leak or enter an area where an asphyxiant gas could be present.
     - Shut off the source of the gas leak if there is no risk to personnel and ventilate the area.
     - If a person has symptoms of asphyxiation, move the victim to fresh air and obtain proper medical attention.
     - Oxygen detection system may be required in areas utilizing cryogenic liquids. Consult with CPDC and/or SBU Fire Marshal to determine requirements for the area/usage.
   - Fire or explosion

   Due to the hazards associated with cryogens, proper PPE is very important when handling them. Users must always wear:
   - Cryo gloves: cryogenically rated, loose fitting gloves. These gloves are for protection from splashes and are not designed to protect against immersion into cryogenic liquids. Use wooden or rubber tongs to remove small items immersed in cryogenic liquid dewars/baths.
   - Close toed and heeled shoes
   - Safety goggles and face shield
   - Apron or lab coat

   Transfer cryogenic liquids:
   - Into dewars, slowly to minimize boiling and splashing of the liquid
   - Only in well – ventilated areas to prevent possible accumulation of inert gas, which can displace oxygen.

- To not more than 80% capacity

2. Flammable gases:

- Keep all sources of ignition away from flammable gas cylinders and ensure that they will not leak.
- Perform leak checks periodically
- Flash arrestors prevent a flash-back in a line containing flammable gas and are recommended
- Do not interchange regulators, hoses, and other appliances used with cylinders of flammable gases with other gases.
- Keep flammables way from reactive (oxidizers and corrosives) at a distance not less than 20 feet or use a 5 ft fire retardant separation with a minimum 30-minute fire rating or a gas cabinet constructed as per NFPA 30, Flammable and Combustible Liquids Code.
- Prior to introduction of a flammable gas into a reaction vessel, the equipment should be purged by evacuation or with an inert gas. The flush cycle should be repeated three times to reduce the residual oxygen to approximately 1%.
- Use spark proof tools when working with flammable gases
- Gas detection system that detects the presence of gas at or below the Lower Explosive Limit (LEL) is recommended. Consult with CPDC and/or SBU Fire Marshal to determine requirements for the area/usage.
- Do not use vessels or equipment containing copper or alloys contacting more than 50% copper for acetylene.
- Above the Maximum allowed quantity (MAQ) may require additional controls. Consult EHS to determine requirements.

3. Oxygen and Oxidizer Gas:

- All equipment used for such gases must be cleaned with oxygen compatible materials free from oils, grease and other contaminants (hydrocarbon and neoprene).
- Do not use oily hands and/or gloves when handling cylinders
- Oxygen leaks may create an oxygen rich environment which can increase the risk of fire and explosions
- Oxidizers react explosively with flammable gases.
- Building/Fire code piping and storage requirements may apply, please contact Campus Planning and Design and/or SBU Fire Marshal for guidance.
- SBUH covers the use of medical gases in SBUH Policy *EC0028 Compressed Medial Gases*

4. Toxic Gases (with a GHS rating of 1 or 2)

- The amount of toxicity and the hazards associated will differ depending on the gas. Safety Data Sheet should be consulted prior to using.
- Must be stored in exhausted enclosures such as a gas cabinet. Smaller tanks and lecture bottles may be stored in chemical fume hoods.
- The quantity must be kept to a minimum.
- Must not be used and/or stored outside academic or research laboratories
- A gas detection system, with visible and audible alarms to detect the presence of leaks may be required if the physiological warning properties for the gas are above the permissible exposure level or ceiling limit of the gas. Consult with CPDC and/or SBU Fire Marshal to determine requirements for the area/usage.
- Special handling procedures and precautions must be documented in the laboratory SOP.

5. Corrosive Gases

- Use in fume hood or other vented enclosure when possible.
- Emergency Eyewash/Safety Shower shall near the vicinity of use
- Equipment and tubing must be checked frequently for leaks as metals become brittle overtime when used with corrosive gases.
- Safety plugs on the valves of chlorine cylinders fuse at 157°F. Care must be exercised to see that they are not exposed to steam, hot water, etc. which could produce this temperature.
- Chlorine leaks may be located using a cloth wet with aqua-ammonia which will produce white fumes (ammonia chloride) in the presence of chlorine. NOTE: This procedure may only be performed with appropriate respiratory protection. For any individual to wear a respirator, he/she must have written physician's approval, attend a respiratory protection training session, and pass a respirator fit test. Training and fit testing are provided by the Department of Environmental Health and Safety.

D. Emergencies

1. Preventing and Controlling Leaks

- Check cylinders, connections, hoses regularly for leaks
- Methods to check for leaks include:
  - Flammable gas leak detector (for flammable gases only)

- For flammable, oxidizing, or highly toxic gases: use an inert gas to check for leaks before introducing the hazardous gas
- Application of soapy water or a 50% glycerin-water solution and looking for bubbles
- For gases at or below freezing temperatures: use glycerin solution
- Leak test solutions specially designed for oxygen leaks are available; (do not use soap solutions as they may contain oils that can react violently with oxygen)

2. **In the event of a leak**,
   - If possible and it is safe, attempt to turn off the cylinder at the valve
   - Evacuate the building or area. Activate the fire alarm by pulling the nearest fire alarm box.
   - Call University Police: 631-632-3333 (from a cell phone) or x333 from a campus phone

3. **Laboratory Emergency Plan**

   Must be prepared and updated wherever compressed gases or cryogenic fluids are produced, handled, stored or used. The plan must include the following information:
   - The type of emergency equipment available and its location (e.g. emergency eyewash & shower, fire extinguisher).
   - A safety data sheet (SDS) for each compressed gas or cryogenic fluid or list with name of gas, hazard class, and quantity, stored or used in the area.
   - A list of personnel who are designated and trained to be liaison personnel for the fire department/emergency responders and who are responsible for the following:
     - Aiding the emergency responders in pre-emergency planning
     - Identifying the location of the compressed gases and cryogenic fluids stored or used
     - Accessing safety data sheets
     - Knowing the site emergency procedures.

Forms: N/A

Policy Cross Reference: SBUH EC0028 Compressed Medical Gases

Relevant Standards/Codes/Rules/Regulations/Statutes:

OSHA 29 CFR 1910.101 Compressed Gases (general requirements)

CGA P-1 2015: *Standard for Safe Handling of Compressed Gases in Containers, 12th Edition*

NFPA 45: *Standard on Fire Protection for Laboratories Using Chemicals, 2015 Edition*

NFPA 55: *Compressed Gases and Cryogenic Fluids Code, 2016 Edition*

References and Resources:

Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, 2011; *the National Academy of Sciences*.

Handbook of Compressed Gases, Fourth Edition, Compressed Gas Association, Inc.