



West Virginia University®

ENVIRONMENTAL HEALTH & SAFETY

# **COMPRESSED GAS CYLINDER SAFETY PROGRAM**

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WEST VIRGINIA UNIVERSITY  
COMPRESSED GAS CYLINDER SAFETY PROGRAM

NFPA 45; NFPA 55; [29 CFR 1910.101](#); [29 CFR 1910.253](#); [29 CFR 1926.350](#)

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## **I. Definitions**

**Absolute Pressure:** Pressure based on a zero reference point, the perfect vacuum.

**Approved:** Acceptable to the authority having jurisdiction

**ASME:** American Society of Mechanical Engineers

**ASTM:** American Society for Testing and Materials

**Authority Having Jurisdiction (AHJ):** An organization, office or individual responsible for enforcing the requirements of a code or standard or for approving equipment, materials installation or a procedure. For the purpose of this section it is the West Virginia Fire Marshals' Office.

**Automatic Emergency Shutoff Valve:** A designated fail-safe automatic closing valve designed to shut off the flow of gases or liquids that is initiated by a control system where the control system is activated by either manual or automatic means.

**Building:** Any structure used or intended for supporting or sheltering any use or occupancy.

**Building Code:** The building or construction code adopted by the jurisdiction.

**Bulk Hydrogen Compressed Gas System:** An assembly of equipment, consisting of but not limited to, storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds, and piping with a storage capacity of more than 400 ft<sup>3</sup> of compressed hydrogen gas including unconnected reserves on hand at the site. The bulk system terminates at the point where the gas supply, at service pressure first enters the supply line. The containers are either stationary or movable and the source gas is stored as a compressed gas.

**Bulk Inert Gas System:** An assembly of equipment consisting of but not limited to, storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds and piping, with a storage capacity of more than 20,000 ft<sup>3</sup> of inert gas including unconnected reserves on hand at the site. The bulk system terminates at the point where the gas supply, at the service pressure, first enters the supply line. The containers are either stationary or movable and the source gas is stored as a compressed gas or cryogenic fluid.

**Bulk Liquefied Hydrogen Gas System:** An assembly of equipment consisting of but not limited to, storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds and piping, with a storage capacity of more than 39.7 gallons of liquefied hydrogen including unconnected reserves on hand at the site. The bulk system terminates at the point where the gas supply, at service pressure, first enters the supply line. The containers are either stationary or movable and the source gas is stored as a cryogenic fluid.

**Bulk Oxygen System:** An assembly of equipment, such as oxygen storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds, and interconnecting piping, with a storage capacity of more than 20,000 ft<sup>3</sup> of oxygen including unconnected reserves on hand at the site. The bulk oxygen system terminates at the point where oxygen, at service pressure, first enters the supply line. The oxygen containers are either stationary or movable and the source gas is stored as a compressed gas or as a cryogenic liquid.

**Ceiling Limit:** The maximum concentration of an airborne contaminant to which a person might be exposed. The ceiling limits utilized are those published in 29 CFR 1910.1000.

**CFR:** Code of Federal Regulations

**CGA:** Compressed Gas Association

**Combustible Liquid:** A liquid having a closed-cup flash point at or above 100°F (37.8°C), subdivided as follows: Class II liquids have a flash point at or above 100°F (37.8°C) and below 140°F (60°C); Class IIIA liquids have a flash point at or above 140°F (60°C) and below 200°F (93.4°C); Class IIIB liquids have a flash point at or above 200°F (93.4°C).

**Compressed Gas:** A material or mixture of materials that is a gas at 20°C (68°F) or less at an absolute pressure of 14.696 psia and that has a boiling point of 20°C (68°F) at an absolute pressure of 14.7 psia and that is liquefied, nonliquefied or in solution, except those gases that have no other health or physical hazard properties are not considered to be compressed gases until the pressure in the package exceeds an absolute pressure of 40.6 psia at 20°C (68°F).

**Compressed Gas Container:** A pressure vessel designed to hold compressed gas at an absolute pressure greater than one (1) atmosphere at 20°C (68°F) that include cylinders, containers and tanks.

**Compressed Gas System:** An assembly of equipment designed to contain, distribute or transport compressed gases.

**Container:** A vessel. Such as a cylinder, portable tank or stationary tank, that varies in shape, size and material of construction.

**Continuous Gas Detection System:** A gas detection system in which the instrument is maintained in continuous operation and the interval between sampling of any point does not exceed 30 minutes.

**Control Area:** A designated area, either indoors or outdoors within which limited quantities of hazardous materials are allowed to be stored, used, handled or dispensed.

**Corrosive Gas:** A gas that causes visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact.

**Court:** An open, uncovered, unoccupied space, unobstructed to the sky, bounded on three or more sides by exterior walls.

**Cryogenic Fluid:** A fluid with a boiling point lower than -90°C (-130°F) at an absolute pressure of 14.7psia.

**Cylinder:** A pressure vessel designed for pressures higher than 40 psia and having a circular cross-section. It does not include a portable tank, multiunit tank car tank, cargo tank or tank car.

**Cylinder Containment System:** A gastight recovery system comprised of equipment or devices that can be placed over a leak in a compressed gas container, thereby stopping or controlling the escape of gas from the leaking container.

**Cylinder Pack:** An arrangement of cylinders into a cluster where the cylinders are confined into a grouping or arrangement with a strapping or frame system and connections are made to a common manifold. The frame system is allowed to be on skids or wheels to permit movement.

**Cylinder Containment Vessel:** A gastight recovery vessel designed so that a leaking compressed gas container can be placed within its confines, thereby encapsulating the leaking container.

**Detached Building:** A separate building that is separated from other structures or uses as required by NFPA 5000 for a freestanding structure.

**Distributor:** A business engaged in the sale or resale or both of compressed gases or cryogenic fluids or both.

**DOT:** United States Department of Transportation

**Emergency Shutoff Valve:** A designated valve designed to shut off the flow of gases or liquids.

**Enclosed Court:** A court bounded on all sides by the exterior walls of a building or by the exterior walls and lot lines on which walls are permitted.

**Excess Flow Control:** A fail-safe system or approved means designed to shut off flow due to a rupture in pressurized piping systems.

**Exhausted Enclosure:** An appliance or piece of equipment that consists of a top, a back and two sides that provides a means of local exhaust for capturing gases, fumes, vapors and mists.

**Explosion Control:** A means either preventing an explosion through the use of explosion suppression, fuel reduction or oxidation reduction systems or a means to prevent the structural collapse of a building in the event of an explosion through the use of deflagration venting, barricades or related construction methods.

**Flammable Gas:** A material that is a gas at 20°C (68°F) or less at an absolute pressure of 14.7 psia, that is ignitable at an absolute pressure of 14.7 psia when in a mixture of 13 percent or less by volume with air or that has a flammable range at an absolute pressure of 14.7 psia with air of at least 12 percent regardless of the lower limit.

**Flammable Liquefied Gas:** A liquefied compressed gas that, when under charged pressure, is partially liquid at a temperature of 20°C (68°F) and is flammable.

**Flammable Liquids:** Class I, any liquid having a closed-cup flash point below 100°F (37.8°C).

**Gallon:** A standard U.S. gallon.

**Gas Cabinet:** A fully enclosed, noncombustible enclosure used to provide an isolated environment for compressed gas cylinders in storage and use.

**Gas Manufacturer/Producer:** A business that produces compressed gases or cryogenic fluids or both or fills portable or stationary gas containers, cylinders or tanks.

**Gas Room:** A separately ventilated, fully enclosed room which only compressed gases, cryogenic fluids, associated equipment and supplies are stored or used.

**Gaseous Hydrogen System:** A system in which the hydrogen is delivered, stored and discharged in the gaseous form to a piping system. The gaseous hydrogen system terminates at the point where hydrogen at service pressure first enters the distribution piping.

**Handling:** The deliberate movement of material in containers by any means to a point of storage or use.

**Hazard Rating:** The numerical rating of the health, flammability and self-reactivity and other hazards of the material, including its reaction with water as specified in NFPA 704, Standard System for the Identification of the Hazards of Materials for Emergency Response.

**Highly Toxic Gas:** A chemical that has a median lethal concentration (LC<sub>50</sub>) in air of 200ppm by volume or less of gas or vapor or 2 mg/L or less of mist, fume or dust, when administered by continuous inhalation for 1 hour (or less if death occurs) to albino rats weighing between 200 grams and 300 grams each.

**Immediately Dangerous to Life and Health (IDLH):** A concentration of airborne contaminants, normally expressed in parts per million (ppm) or milligrams per cubic meter that represents the maximum level from which one could escape within 30 minutes without any symptoms or irreversible health effects.

**“in use”:** the status of a cylinder with a regulator properly attached, ready, and intended for use.

**Indoor Area:** An area that is within a building or structure having overhead cover, other than a structure qualifying as “weather protection”.

**Inert Gas:** A nonreactive, nonflammable, noncorrosive gas such as argon, helium, krypton, neon, nitrogen and xenon.

**Irritant Gas:** A chemical that is not corrosive but that causes a reversible inflammatory effect on living tissue by chemical action at the site of contact. A chemical is a skin irritant if, when tested on the skin of albino rabbits by the method of 16 CFR 1500.41 for an exposure of 4 or more hours or by other appropriate techniques, it results in an empirical score of 5 or more. A chemical is classified as an eye irritant if so determined under the procedure listed in 16 CFR 1500.42 or other appropriate techniques.

**ISO Module:** An assembly of tanks or tubular cylinders permanently mounted in a frame conforming to International Organization for Standardization (ISO) requirements.

**Labeled:** Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

**Limited Combustible:** A building construction material not complying with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu/lb, where tested in accordance with NFPA 259, Standard Test Method for Potential Heat of Building Materials, and complies with (a) or (b): (a) materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 1/8 inch that has a flame spread index not greater than 50; and (b) materials, in the form and thickness used other than as described in (a), having neither a flame spread index greater than 25 nor evidence of continued progressive combustion and of such combustion that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion. (Materials subject to increase the combustibility or flame spread index beyond the limits herein established through the effects of age, moisture or other atmospheric condition shall be considered combustible).

**Liquefied Hydrogen System:** A system into which liquefied hydrogen is delivered and stored and from which it is discharged in the liquid or gaseous form to a piping system. The system originates at the storage container fill connection and terminates at the point where hydrogen at service pressure first enters the sup[ply line.

**Listed:** Equipment, materials or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintain periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states that either equipment, material or service meets appropriate designated standards or has been tested and found suitable for specified purpose.

**Manual Emergency Shutoff Valve:** A designated valve designed to shut off the flow of gases or liquids that is manually operated.

**Safety Data Sheet (SDS):** Written or printed material concerning a hazardous material that is prepared in accordance with the provisions of 29 CFR 1910.1200.

**Maximum Allowable Quantity Per Control Area (MAQ):** A threshold quantity of hazardous materials in a specific hazard class that once exceeded requires the application of additional administrative procedures, construction features or engineering controls.

**Mechanical Code:** The mechanical or mechanical construction code adopted by the jurisdiction.

**Mobile Supply Unit:** Any supply source that is equipped with wheels so it is able to be moved around.

**Nesting:** A method of securing cylinders upright in a tight mass using a contiguous three-point contact system whereby all cylinders in a group have a minimum of three points with other cylinders or a solid support structure (for example, a wall or railing).

**Noncombustible Material:** A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion or release flammable vapors, when subjected to fire or heat. Materials that are reported as passing ASTM E 136 are considered noncombustible materials.

**Non-Flammable Gas:** A gas that does not meet the definition of a flammable gas.

**Normal Temperature and Pressure (NTP):** A temperature of 21°C (70°F) at an absolute pressure of 14.7 psia.

**OSHA:** The Occupational Safety and Health Administration of the United States Department of Labor.

**Other Gas:** A gas that is not a corrosive gas, flammable gas, highly toxic gas, oxidizing gas, pyrophoric gas, toxic gas, or an unstable reactive gas with a hazard rating of Class 2, Class 3 or Class 4.

**Outdoor Area:** An area that is not an indoor area.

**Oxidizing Gas:** A gas that can support and accelerate combustion of other materials.

**Permissible Exposure Limits (PEL):** The maximum permitted 8-hour, time weighted average concentration of an airborne contaminant.

**Portable Tank:** Any packaging over 60 U.S. Gallons in capacity designed primarily to be loaded into or on or temporarily attached to a transport vehicle or ship and equipped with skids, mountings or accessories to facilitate handling of the tank by mechanical means.

**Protection Level 1:** Occupancies used for the storage or use of unstable reactive Class 4 and unstable reactive Class 3 detonable compressed gases in quantities that exceed the thresholds for gases requiring special provisions shall be classified Protection Level 1.

**Protection Level 2:** Occupancies used for the storage or use of flammable, pyrophoric and non-detonable, unstable reactive Class 3 compressed gases or cryogenic fluids in quantities that exceed the quantity thresholds for gases requiring special provisions shall be classified as Protection Level 2.

**Protection Level 3:** Occupancies used for the storage or use of oxidizing and unstable reactive Class 2 compressed gases or cryogenic fluids in quantities that exceed the quantity thresholds for gases requiring special provisions shall be classified as Protection Level 3.

**Protection Level 4:** Occupancies used for the storage or use of toxic, highly toxic and corrosive compressed gases in quantities that exceed the quantity thresholds for gases requiring special provisions shall be classified as Protection Level 4.

**Protection Level 5:** Buildings and portions thereof used for fabrication of semiconductors or semiconductor research and development and containing quantities of hazardous materials exceeding the maximum allowable quantities of high hazard level 5 contents permitted in control areas shall be classified as Protection Level 5.

**Pyrophoric Gas:** A gas with an auto-ignition temperature in air at or below 54.4°C (130°F).

**Qualified Individual:** An individual knowledgeable in the hazards of compressed gases and cryogenic fluids through training and work experience.

**Remotely Located, Manually Activated Shutdown Control:** A control system that is designed to initiate shutdown of the flow of gas or liquid that is manually activated from a point located some distance from the delivery system.

**Separation of Hazards:** Physically separated by a specified distance, construction or appliance.

**Shall:** Indicates a mandatory requirement.

**Short Term Exposure Limit (STEL):** The concentration to which it is believed that workers can be exposed continuously for a short period of time without suffering from irritation, chronic or irreversible tissue damage, or narcosis of a degree sufficient to increase the likelihood of accidental injury, impairment of self-rescue or the material reduction of work efficiency, without exceeding the daily permissible exposure limit (PEL).

**Should:** Indicates a recommendation or that which is advised but not required.

**Standard Cubic Foot of Gas:** Cubic foot of gas at 14.7 psia and 70°F (21°C).

**Stationary Tank:** A packaging designed primarily for stationary installations not intended for loading, unloading or attachment to a transport vehicle as part of the normal operation in the process of use.

**Storage:** An inventory of compressed gases or cryogenic fluids in containers that are not in the process of being examined, services, refilled, loaded or unloaded.

**TC:** Transport Canada.

**Toxic Gas:** A gas with a median lethal concentration (LC50) in air of more than 200 ppm but not more than 2,000 ppm by volume of gas or vapor or more than 2 mg/L, but not more than 20 mg/L or mist, fume or dust when administered by continuous inhalation for 1 hour (or less if death occurs) to albino rats weighing between 200 grams and 300 grams each.

**Treatment System:** An assembly of equipment capable of processing a hazardous gas and reducing the gas concentration to a predetermined level at the point of discharge from the system to the atmosphere.

**Tube Trailer:** A truck or semi-trailer on which a number of very long compressed gas tubular cylinders have been mounted and manifolded into a common piping system.

**Unstable Reactive Gas:** A gas that, in the pure state or as commercially produced, will vigorously polymerize, decompose or condense, become self-reactive or otherwise undergo a violent chemical change under conditions of shock, pressure or temperature.

**Unstable Reactive Gas (Class 2):** Materials that readily undergo violent chemical change at elevated temperatures and pressures.

**Unstable Reactive Gas (Class 3):** Materials that in themselves are capable of detonation or explosive decomposition or explosive reaction but that require a strong initiating source or that must be heated under confinement before initiation.

**Unstable Reactive Gas (Class 4):** Materials that in themselves are readily capable of detonation or explosive decomposition or explosive reaction at normal temperature and pressure.

**Use:** To place a material into action, including solids, liquids and gases.

**Valve Outlet Cap:** A removable device that forms a gastight seal on the outlet to the control valve that is provided on a source containing a compressed gas or cryogenic fluid.

**Valve Protection Cap:** A rigid, removable cover provided for container valve protection during handling, transportation and storage.

**Valve Protection Device:** A device attached to the neck ring or body of a cylinder for the purpose of protection the cylinder valve from being struck or from being damaged by the impact resulting from the fall or an object striking the cylinder.

## **II. General Requirements**

The following are general requirements for compressed gas and cryogenic fluid production, handling, storage and use.

### **A. Emergency Plan**

1. An emergency plan shall be prepared and updated wherever compressed gases or cryogenic fluids are produced, handled, stored or used where required by the Authority Having Jurisdiction (AHJ). Potential authorities having jurisdiction include the West Virginia State Fire Marshal's Office, The West Virginia Division of Labor, the West Virginia Department of Environmental Protection and the City of Morgantown.
2. The plan shall be available for inspection by the AHJ upon reasonable notice and shall include the following information:
  - a. The type of emergency equipment available and its location.
  - b. A brief description of any testing or maintenance programs for the available emergency equipment.
  - c. An indication that hazard identification labeling is provided for each storage area.

- d. The location of posted emergency procedures.
- e. A Safety Data Sheet (SDS) for each compressed gas or cryogenic fluid stored or used on the site.
- f. A list of personnel who are designated and trained to be liaison personnel for the fire department and who are responsible for the following:
  - i. Aid the emergency responders in pre-emergency planning
  - ii. Identify the location of the compressed gases and cryogenic fluids
  - iii. Access safety data sheets
  - iv. Know site emergency procedures
- g. A list of the types and quantities of compressed gases and cryogenic fluids found within the facility.

## **B. Safety Data Sheets**

- 1. Safety Data Sheets shall be readily available on the premises for hazardous materials regulated by this code.

## **C. Release of Compressed Gases and Cryogenic Fluids**

- 1. Prohibited Releases
  - a. Compressed gases and cryogenic fluids shall not be released into a sewer, storm drain, ditch, drainage canal, lake, river or tidal waterway; upon the grounds, sidewalk, street or highway; or into the atmosphere unless such release is permitted by the following:
    - i. Federal, state or local governing regulations.
    - ii. Permits or the jurisdictional air quality management board.
    - iii. National Pollutant Discharge Elimination System Permit.
    - iv. Waste discharge requirements established by the jurisdictional water quality control board.
    - v. Local sewer pretreatment requirements for publicly owned treatment works.
  - b. Provisions shall be made for controlling and mitigating unauthorized discharges. Accurate records of unauthorized discharges of hazardous materials shall be kept. The fire department shall be notified immediately or in accordance with approved emergency procedures when unauthorized discharge becomes reportable under state, federal or local regulations.
- 2. Responsibility for Cleanup of Unauthorized Discharges
  - a. The person, firm or corporation responsible for an unauthorized discharge shall institute and complete all actions necessary to remedy the effects of such unauthorized discharge, whether sudden or gradual at no cost to the jurisdiction.
  - b. When deemed necessary by the AHJ, cleanup of an unauthorized discharge shall be permitted to be initiated by the fire department or by an authorized individual or firm and costs associated with such cleanup shall be borne by the owner, operator or other person responsible for the unauthorized discharge.

## **D. Personnel Training**

- 1. Persons responsible for the operation or utilization of areas in which hazardous materials are stored, dispensed, handled or used shall be familiar with the chemical nature of the materials and the appropriate mitigating actions necessary in the event of fire, leak or spill.

2. Persons responsible for the operation or utilization of areas in which hazardous materials are stored, dispensed, handled or used should attend training upon initial employment, when new hazards are determined, and/or when a deficiency of performance or unsafe behavior has been identified.

#### **E. Fire Department Liaison**

1. Responsible persons shall be designated and trained to be liaison personnel for the fire department.
2. Liaison personnel shall aid the fire department in planning emergency responses and identification of the locations where compressed gases or cryogenic fluids are located and shall have access to Safety Data Sheets and be knowledgeable in the site emergency response procedures.

#### **F. Ignition Source Control**

1. Smoking shall be prohibited in the following locations:
  - a. Within 25 feet of outdoor storage or dispensing areas.
  - b. In rooms or areas where compressed gases or cryogenic fluids are stored, dispensed or used in open systems in amounts requiring a permit in accordance with this code.
2. Open flames and high-temperature devices shall not be used in a manner that creates a hazardous condition.
3. Energy-consuming equipment shall be listed for use with the hazardous materials stored or used.

#### **G. Signs**

1. Requirements
  - a. Signs shall be durable, and the size, color and lettering of signs shall be in accordance with nationally recognized standards.
  - b. Signs shall be in English as the primary language or in symbols allowed by this standard.
  - c. Signs shall not be obscured or removed.
2. Hazard Identification Signs
  - a. Visible hazard identification signs in accordance with NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, shall be placed on the following, except where the AHJ has received a hazardous materials inventory statement in accordance with this code and the omission of the signs is consistent with safety:
    - i. Stationary aboveground tanks
    - ii. Stationary aboveground containers
    - iii. At entrances to locations where hazardous materials are stored, dispensed, used or handle.
    - iv. At other entrances and locations designated by the AHJ.
  - b. The authority having jurisdiction shall be permitted to waive this requirement where consistent with safety.
3. Identification of Containers, Cartons and Packages
  - a. Individual containers, cartons or packages shall be conspicuously marked or labeled in accordance with nationally recognized standards.
4. Identification of Gas Rooms and Gas Cabinets

- a. Gas rooms or gas cabinets containing compressed gases shall be conspicuously labeled as follows: **COMPRESSED GAS.**
  - b. Additional signs at areas of use or storage should notify occupants of the compressed gases present by name.
5. No Smoking Signs
- a. Signs prohibiting smoking shall be provided for an entire site or building or in the following locations:
    - i. In rooms or areas where toxic, highly toxic, corrosive, unstable reactive, flammable, oxidizing or pyrophoric gases are stored or dispensed or used in open systems.
    - ii. Within 25 feet of outdoor storage, dispensing or open use areas.
    - iii. In areas containing open flames.

### **III. Classification of Hazards**

#### **A. Pure Gases**

1. Hazardous materials shall be classified according to hazard categories as follows:
  - a. Physical Hazards, which shall include the following:
    - i. Flammable gas
    - ii. Nonflammable gas
    - iii. Oxidizing gas
    - iv. Pyrophoric gas
    - v. Unstable reactive gas (Class 3 or Class 4)
    - vi. Unstable reactive gas (Class 2 or Class 3)
  - b. Health hazards, which shall include the following:
    - i. Corrosive gas
    - ii. Cryogenic fluid
    - iii. Highly toxic gas
    - iv. Toxic gas
    - v. Irritant gas

#### **B. Other Hazards**

1. Although it is possible that there are other known hazards, the classification of such gases is not within the scope of this standard and they shall be handled, stored or used as an “other gas”.

#### **C. Mixtures**

1. Mixtures shall be classified in accordance with the hazards of the mixture as a whole.

#### **D. Toxicity**

1. The toxicity of gas mixtures shall be classified in accordance with CGA P-20, *Standard for the Classification of Toxic Gas Mixtures* or by testing in accordance with the requirements of 29 CFR 1910.1000 or DOT 49 CFR 173 or ISO 10298, *Determination of toxicity of a gas or gas mixture*.

## **E. Flammability of Gas Mixtures**

1. For gas mixtures other than those containing ammonia and nonflammable gases, flammability of a gas mixture shall be classified in accordance with CGA P-23, *Standard for Categorizing Gas Mixtures Containing Flammable and Nonflammable Components*, or by physical testing in accordance with the requirements of ASTM E 681-01, *Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases)*, or ISO 10156, *Gases and gas mixtures – Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets*.

## **F. Corrosive or Unstable Gases**

1. 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. Examples of such corrosive or unstable gases include the following:
  - a. Acid and alkaline gases
  - b. Gases subject to autopolymerization
  - c. Gases subject to explosive decomposition
2. Cylinders of hydrogen fluoride and hydrogen bromide should be returned to the supplier within 2 years of the shipping date.
3. Cylinders not in active use should be removed from the laboratory work areas to a proper storage facility, as described in CGA Pamphlet P-1, *Safe Handling of Compressed Gases in Containers*. In the absence of a maximum recommended retention time, a 36-month interval should be used.

## **IV. Building Related Controls**

### **A. Cylinder Location/Separation**

1. A second means of access to an exit shall be provided from a laboratory work area should a compressed gas cylinder larger than lecture bottle size [approximately 5 cm x 33 cm (2 in. x 13 in.)] be located so that it could prevent safe egress in the event of an accidental release of cylinder contents.
2. Where possible and safe, compressed gas cylinders should be stored away from all laboratory exits.
3. Control areas shall be separated from each other by not less than a 1-hour fire-resistive occupancy separation.

### **B. Flammable and Oxidizing Gases**

1. Flammable and Oxidizing gases shall not be stored or used in occupancies other than storage or industrial.
2. Containers, cylinders or tanks not exceeding 250 ft<sup>3</sup> content at normal temperature and pressure and used for maintenance purposes, patient care or operation of equipment shall be permitted.

### **C. Toxic and Highly Toxic Compressed Gases**

1. Except for containers or cylinders not exceeding 20 ft<sup>3</sup> content at normal temperature and pressure stored or used within gas cabinets or exhausted enclosures of educational occupancies, toxic or highly toxic compressed gases shall not be stored or used in other than industrial and storage occupancies.
2. The maximum allowable quantity of gases per control area shall be in accordance with **Table One**.

**Table One: Maximum Allowable Quantity (MAQ) of Hazardous Materials per Control Area**

			Storage			Use – Closed Systems			Use – Open Systems	
Material	Class	High Hazard Protection Level	Solid Pounds	Liquid Gallons	Gas scf (lb)	Solid Pounds	Liquid Gallons	Gas scf (lb)	Solid Pounds	Liquid Gallons
Cryogenic Fluid	Flammable	2	NA	45	NA	NA	45	NA	NA	45
	Oxidizing	3	NA	45	NA	NA	45	NA	NA	45
	Inert	NA	NA	NL	NA	NA	NL	NA	NA	NL
Flammable, gas	Gaseous	2	NA	NA	1000	NA	NA	1000	NA	NA
	Liquefied	2	NA	NA	(150)	NA	NA	(150)	NA	NA
	LP	2	NA	NA	(300)	NA	NA	(300)	NA	NA
Inert gas	Gaseous	NA	NA	NA	NL	NA	NA	NL	NA	NA
	Liquefied	NA	NA	NA	NL	NA	NA	NL	NA	NA
Oxidizing gas	Gaseous	3	NA	NA	1500	NA	NA	1500	NA	NA
	Liquefied	3	NA	NA	(1500)	NA	NA	(150)	NA	NA
Pyrophoric gas	Gaseous	2	NA	NA	50	NA	NA	50	NA	NA
	Liquefied	2	NA	NA	(4)	NA	NA	(4)	NA	NA
Unstable (reactive) gas	Gaseous									
	4 or 3 detonable	1	NA	NA	10	NA	NA	10	NA	NA
	3 nondetonable	2	NA	NA	50	NA	NA	50	NA	NA
	2	3	NA	NA	750	NA	NA	750	NA	NA
Unstable (reactive) gas	1	NA	NA	NA	NL	NA	NA	NL	NA	NA
	Liquefied									
	4 or 3 detonable	1	NA	NA	(1)	NA	NA	(1)	NA	NA
	3 nondetonable	2	NA	NA	(2)	NA	NA	(2)	NA	NA
Corrosive gas	Gaseous	4	NA	NA	810	NA	NA	810	NA	NA
	Liquefied		NA	NA	(150)	NA	NA	(150)	NA	NA
Highly toxic gas	Gaseous	4	NA	NA	20	NA	NA	20	NA	NA
	Liquefied		NA	NA	(4)	NA	NA	(4)	NA	NA
Toxic gas	Gaseous	4	NA	NA	810	NA	NA	810	NA	NA
	Liquefied		NA	NA	(150)	NA	NA	(150)	NA	NA

NA: Not applicable within the context of NFPA 55 (refer to the applicable building or fire code for additional information on these materials).

NL: Not limited in quantity.

Notes:

(1) For use of control areas, see Section 6.2.

(2) Table values in parentheses or brackets correspond to the unit name in parentheses or brackets at the top of the column.

(3) The aggregate quantity in use and storage is not permitted to exceed the quantity listed for storage. In addition, quantities in specific occupancies are not permitted to exceed the limits in the building code.

<sup>a</sup>Measured at NTP [70°F (20°C) and 14.7 psi (101.3kPa)].

<sup>b</sup>None allowed in unsprinklered buildings unless stored or used in gas rooms or in approved gas cabinets or exhausted enclosures, as specified in this code.

<sup>c</sup>With pressure-relief devices for stationary or portable containers vented directly outdoors or to an exhaust hood.

<sup>d</sup>Quantities are permitted to be increased 100 percent where stored or used in approved cabinets, gas cabinets, exhausted enclosures, gas rooms, as appropriate for the material stored. Where Footnote e also applies, the increase for the quantities in both footnotes is permitted to be applied accumulatively.

<sup>e</sup>Maximum quantities are permitted to be increased 100 percent in buildings equipped throughout with an automatic sprinkler system in accordance with NFPA 13. Where Footnote d also applies, the increase for the quantities in both footnotes is permitted to be applied accumulatively.

<sup>f</sup>Flammable gases in the fuel tanks of mobile equipment or vehicles are permitted to exceed the MAQ where the equipment is stored and operated in accordance with the applicable fire code.

<sup>g</sup>See NFPA 58 for requirements for liquefied petroleum gas (LP-Gas). LP-Gas is not within the scope of NFPA 55.

<sup>h</sup>Additional storage locations are required to be separated by a minimum of 300 ft (92 m)

<sup>i</sup>In mercantile occupancies, storage of LP-Gas is limited to a maximum of 200 lb (91 kg) in nominal 1 lb (0.45 kg) LP-Gas containers.

<sup>j</sup>Permitted only in buildings equipped throughout with an automatic sprinkler system in accordance with NFPA 13.

<sup>k</sup>Allowed only where stored or used in gas rooms or in approved gas cabinets or exhausted enclosures, as specified in this code.

## **D. Gas Rooms**

1. Gas rooms shall be operated at a negative pressure in relationship to the surrounding area. Gas rooms shall be provided with an exhaust ventilation system.
2. Gas rooms shall be separated from other occupancies by a minimum of 1-hour fire resistance.
3. The function of compressed gas rooms shall be limited to storage and use of compressed gases and associated equipment and supplies.
4. Lighting by natural or artificial means shall be provided.

## **E. Shelving**

1. Shelves used for the storage of cylinders, containers and tanks shall be of noncombustible construction and designed to support the weight of materials stored.
2. In seismically active areas, shelves and containers shall be secured from overturning.

## **F. Ventilation**

1. Indoor Storage
  - a. Indoor storage and use areas and storage buildings for compressed gases and cryogenic fluids shall be provided with mechanical exhaust ventilation or natural ventilation, where natural ventilation can be shown to be acceptable for the materials stored.
2. Vent Pipe Termination
  - a. The termination point for piped vent systems serving cylinders, containers, tanks and gas systems used for the purpose of operational or emergency venting shall be located to prevent impingement exposure on the system served and to minimize the effects of high temperature thermal radiation or the effects of contact with gas from the escaping plume to the supply system, personnel, adjacent structures and ignition sources.
3. Mechanical Exhaust Ventilation
  - a. Where mechanical exhaust ventilation is provided, the system shall be operational during the time the building space is occupied.
  - b. Mechanical ventilation shall be at a rate of not less than 1 ft<sup>3</sup>/minute/ft<sup>2</sup> of floor area over the area of the storage or use.
  - c. Systems shall operate continuously unless an alternate design is approved by the code official.

- d. Where powered ventilation is provided, a manual shutoff switch shall be provided outside of the room in a position adjacent to the principal access door to the room or in an approved location.
  - e. The switch shall be the break glass or equivalent type and shall be labeled as follows:  
WARNING: VENTILATION SYSTEM EMERGENCY SHUTOFF
4. Inlets to the Exhaust System
- a. The exhaust ventilation system design shall take into account the density of the potential gases released.
  - b. For gases that are heavier than air, exhaust shall be taken from a point within 12 inches of the floor.
  - c. For gases that are lighter than air, exhaust shall be taken from a point 12 inches from the ceiling.
  - d. The location of both the exhaust and inlet openings shall be designed to provide air movement across all portions of the floor or room to prevent the accumulation of vapors.
  - e. Exhaust ventilation shall not be re-circulated within the room or building if the cylinders, containers or tanks stored are capable of releasing hazardous gases.
5. Ventilation Discharge
- a. Ventilation systems shall discharge a minimum of 50 feet from intakes of air handling systems, air-conditioning equipment and air compressors.
6. Air Intakes
- a. Storage and use of compressed gases shall be located not less than 50 feet from air intakes.
7. Gas Cabinets
- a. Where a gas cabinet is required, is used to provide separation of gas hazards or is used to increase the threshold quantity for a gas requiring special provisions, the gas cabinet shall meet the following standards.
  - b. The gas cabinet shall be constructed of not less than 2.46mm (12 gauge) steel.
  - c. The gas cabinet shall be provided with self-closing limited access ports or noncombustible windows to give access to equipment controls.
  - d. The gas cabinet shall be provided with self-closing doors.
8. Ventilation Requirements
- a. The gas cabinet shall be provided with an exhaust ventilation system designed to operate at a negative pressure relative to the surrounding area.
  - b. Where toxic; highly toxic; pyrophoric; unstable reactive Class 3 or Class 4; or Corrosive gases are contained, the velocity at the face of access ports or windows, with the access port or window open, shall not be less than 200 feet/minute average, with not less than 150 feet/minute at any single point.
  - c. Gas cabinets used to contain toxic, highly toxic or pyrophoric gases shall be internally sprinklered.
  - d. Gas cabinets shall not contain more than three cylinders, tanks or containers.
  - e. Incompatible gases shall be stored or used within separate gas cabinets.

## **V. Compressed Gases**

### **A. Safety Tips**

1. General Hazards
  - a. Thoroughly know the hazards of the gas in use. All compressed gases have the pressure hazard, but a gas can also have more hazards; gases can be toxic, corrosive, flammable, asphyxiating, oxidizing, pyrophoric, and/or reactive. All these factors can impact the design of the system and how the gases are utilized.
2. Eye Protection
  - a. Always wear eye protection when working on or near compressed gas systems. Do not allow others to enter a compressed gas cylinder storage area or where compressed gases are in use without proper eye protection.
3. Training
  - a. Ensure all individuals responsible for operation or utilization of compressed gases are appropriately trained and knowledgeable in the dangers of pressure, the chemical properties of the gases in use, and the proper Compressed Gas Association (CGA) compressed gas fittings and connections.
4. Cylinder Identification
  - a. Do not use a compressed gas cylinder that is not clearly marked or labeled with the cylinder's contents. Reject any cylinder that is unmarked or has conflicting markings or labels. Never rely on the color of the cylinder to identify the contents. If there is any conflict or doubt concerning the contents, do not use the cylinder. Return it to the vendor.
5. Cylinder Content
  - a. Be certain that the content of the cylinder is the correct product for use in the system to which it is being connected.
6. Regulator Use
  - a. Never use a compressed gas cylinder without a pressure-reducing regulator or device that will safely reduce the cylinder pressure to the desired pressure of the system. Only use regulators that have both a high-pressure gauge and a low-pressure gauge. This allows for the monitoring of both the pressure in the compressed gas cylinder and the pressure in the system.
7. Pressure Gauge Use
  - a. As per ANSI B 40.1, *Pressure Gauges and Gauge Attachments*, never use a gauge above 75 percent of its maximum face reading. For example, a 20,700 kPa (3,000 psi) system should use at least 27,600 kPa (4,000 psi) gauges. If the system can achieve a maximum pressure of 517 kPa (75 psi), the gauge monitoring system should be at least 690 kPa (100 psi). (Immediately replace any gauge in which the pointer does not go back to its zero point when pressure is removed.)
8. Valves
  - a. Be sure the valve on the compressed gas cylinder and the pressure-reducing regulator in use have the proper CGA connections for the pure gas (CGA V-1) or gas mixture (CGA V-7) in use. Never use an adaptor between a cylinder and a pressure-reducing regulator.
9. Proper Connection

- a. Be certain that the CGA connection(s) on the cylinder and the pressure-reducing regulator fit together properly without being too loose or too tight. Proper connections will go together smoothly. Never use excessive force to connect a CGA connection. Never use an aid, such as a pipe dope or Teflon<sup>®</sup> tape, to connect a regulator to a cylinder.

#### 10. Connections

- a. Be certain that the pressure-reducing regulator in use is compatible with the gas, and be certain that it is rated and marked for the maximum pressure rating of the CGA connection on the compressed gas cylinder valve being attached to it. All compressed gas cylinder connections can be found listed with their recommended gases and the maximum allowed pressures in CGA/ANSI V-1, *Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections*.

#### 11. Regulator Compatibility

- a. Never replace the CGA connection that the regulator manufacturer has put on a regulator with one for a different gas service. Only the regulator manufacturer or trained service representative know the gas compatibility of the regulator's internal design and can properly reclean the regulator.

#### 12. Procedures

- a. After attaching a pressure-reducing regulator to a compressed gas cylinder, do the following:
  - i. Turn the regulator's adjustment screw out (counterclockwise) until it feels loose.
  - ii. Stand behind the cylinder with the valve outlet facing away from you.
  - iii. Observe the high-pressure gauge on the regulator from an angle; do not pressurize a gauge while looking directly at the glass or plastic faceplate.
  - iv. Open the valve handle on the compressed gas cylinder slowly, until one can hear the space between the cylinder valve gently fill the gas. (One can also watch the pressure rise on the high-pressure gauge. If the regulator is properly adjusted, then no gas should flow out of the regulator or pressure rise on the low-pressure gauge.
  - v. Ensure purity of a nontoxic, nonflammable gas by shutting off the cylinder valve and gently cracking the CGA connection at the cylinder valve. (Generally, three pressurizations with venting will ensure the interior of the connection has a clean, representative sample of the gas in the compressed gas cylinder. For toxic or flammable gases, a special venting regulator can be purchased to safely vent to a fume hood or vented gas cabinet.
  - vi. When ready to use the compressed gas cylinder, fully open the cylinder valve until it stops. Then, close it one-quarter turn. (A fully open valve that has no play in it can confuse a person who is checking to see if it is open. Many accidents have been recorded by people trying to open a previously fully opened valve by using a large wrench.)
  - vii. Use the following practices on acetylene cylinders to allow quick closing of the valve in the event of an emergency:
    - 1. Open acetylene cylinder valves no more than one and one-half turns.
    - 2. Leave the wrench on the valve spindle when the cylinder is being used, if the acetylene cylinder has a T-wrench instead of a hand-wheel valve.

### 13. Pressure Relief

- a. Make sure any system being pressurized (piping, manifolds, containers, etc.) that can be isolated or closed off has its own pressure-relief device. It is the user's responsibility to see that the system has proper pressure-relief device(s) built into it. Do not rely on the relief device on the compressed gas cylinder's regulator; it is not designed to protect downstream systems. This is very critical when cryogenic liquids are used. Pressure-relief discharge points should be vented to safe locations (not directed toward people or routed to safe locations for hazardous gases.)

### 14. Cylinders Not in Use

- a. Shut off cylinders that are not in use. Always have a cylinder cap on any cylinder that is being stored or is not in use.

### 15. Backflow Precautions

- a. Use backflow check valves where flammable and oxidizing gases are connected to a common piece of equipment or where low- and high-pressure gases are connected to a common set of piping. Do not rely on a closed valve to prevent backflow.

### 16. Pressure Relief

- a. The relief device on a cylinder of liquefied flammable gas (generally found on the cylinder valve) always should be in direct contact (communication) with the vapor space of the cylinder in both use and storage. Never lay a cylinder of liquefied flammable gas on its side unless it is so designed (and so marked) to allow that positioning, as in the case of propane cylinders for forklift trucks.

### 17. Protection of Cylinders in Use

- a. Cylinders in use should be secured by a holder or device specifically designed to secure a cylinder. Never stand a single cylinder in an open area unsecured. Always protect cylinders from danger or overhead hazards, high temperatures, and other sources of damage, such as vehicle traffic.

### 18. Moving Cylinders

- a. Always use a cylinder cart to move large cylinders or specially designed cylinder holders to carry small cylinders. Never pick up a cylinder by its cap.

### 19. Refilling

- a. Never refill a cylinder or use a cylinder for storing any material. If gas is accidentally forced back or sucked back into a cylinder, mark the cylinder well and inform the gas supplier. (Almost all recent deaths involving compressed gas cylinders occurred as users were putting gas back into cylinders and fillers at the compressed gas plants.)

### 20. Asphyxiation

- a. Possibly the greatest hazard to a user of compressed gases – and especially users of cryogenic fluids – is asphyxiation. Remember that, except for oxygen and for air with at least 19.5 percent oxygen, all gas is an asphyxiant. Vent gas only into safe and properly ventilated locations outside the building or fume hood. Exposure to an atmosphere that has 12 percent or less oxygen will bring about unconsciousness without warning and so quickly that the individuals cannot help or protect themselves.

### 21. Cryogenic Gases

- a. When transferring cryogenic gases inside or have equipment using cryogenic gases that vents anything more than a few cubic centimeters of gas per minute inside (i.e., not to a

hood), adequate 24-hour ventilation and continuous oxygen meter(s)/monitor(s) with a “low oxygen” alarm should be installed.

22. Remember, all compressed gases are hazardous; understand those hazards completely and design the system accordingly. The major compressed gas vendors have technical expertise available to support users. Never become complacent when using a compressed gas. Always respect the hazards and treat them accordingly.

## **B. Containers**

1. Compressed gas cylinders, containers or tanks containing residual product shall be treated as full except when being examined, serviced or refilled by a gas manufacturer or distributor.
2. Defective cylinders, containers, and tanks shall be returned to the supplier.

## **C. Labels and Markings**

1. Individual compressed containers, cylinders and tanks shall be marked or labeled in accordance with USDOT requirements or those of the applicable regulatory agency.
2. The labels applied by the gas manufacturer to identify the liquefied or nonliquefied compressed gas cylinder contents shall not be altered or removed by the user.
3. Markings shall be visible from any direction of approach.

## **D. Piping Systems**

1. Piping systems shall be marked in accordance with ASME A13.1, *Scheme for the Identification of Piping Systems*, or other applicable approved standards as follows:
  - a. Marking shall include the name of the gas and direction-of-flow arrow.
  - b. Piping that is used to convey more than one gas at various times shall be marked to provide clear identification and warning of the hazard.
  - c. Marking for piping systems shall be provided at the following locations:
    - i. At each critical control valve
    - ii. At wall, floor or ceiling penetrations
    - iii. At each change of direction
    - iv. At a minimum of every 20 feet or fraction thereof throughout the piping run

## **E. Security and Physical Protection**

1. Compressed gas containers, cylinders and tanks shall be secured against accidental dislodgement and against access by unauthorized personnel.
2. Compressed gas containers, cylinders and tanks that could be exposed to physical damage shall be protected.
3. Guard posts or other means shall be provided to protect compressed gas containers, cylinders or tanks indoors and/or outdoors from vehicular damage.
4. Compressed gas containers, cylinders or tanks in use or storage shall be secured to prevent them from falling or being knocked over by corralling them and securing them to a fixed object by use of a restraint.
5. Compressed gas container, cylinder and tank valves shall be protected from physical damage by means of protective caps, collars or similar devices.
6. Where compressed gas containers, cylinders and tanks are designed to accept valve-protective caps, the user shall keep such caps on the compressed gas container, cylinder or tank at all times, except when being processed or connected for use.

- Gastight valve outlet caps or plugs shall be provided and in place for all full, partially full containers, cylinders and tanks containing toxic, highly toxic, pyrophoric, unstable reactive class 3 or unstable reactive class 4 gases that are in storage.

**F. Separate from Hazardous Conditions**

- Compressed gas containers, cylinders and tanks in storage or use shall be separated from materials and conditions that present exposure hazards to or from each other.
- Compressed gas containers, cylinders and tanks in storage or use shall be separated in accordance with **Table Two**.

**Table Two: Separation of Gas Cylinders, Containers, and Tanks by Hazard Class**

Gas Category	Reactive Class 2, 3 or 4	Corrosive	Oxidizing	Flammable	Pyrophoric	Toxic or Highly Toxic	Other Gas
Toxic or Highly Toxic	20 feet	20 feet	20 feet	20 feet	20 feet	NA	Not Required
Pyrophoric	20 feet	20 feet	20 feet	20 feet	NA	20 feet	Not Required
Flammable	20 feet	20 feet	20 feet	NA	20 feet	20 feet	Not Required
Oxidizing	20 feet	20 feet	NA	20 feet	20 feet	20 feet	Not Required
Corrosive	20 feet	NA	20 feet	20 feet	20 feet	20 feet	Not Required
Reactive Class 2, 3 or 4	NA	20 feet	Not Required				
Other Gas	Not Required	Not Required	Not Required	Not Required	Not Required	Not Required	NA

- The 20 foot distance shall be permitted to be reduced without limit when separated by a barrier of noncombustible materials at least 5 feet high that has a fire resistance rating of at least 30 minutes.
- The 20 foot distance shall be permitted to be reduced to 5 feet where one of the gases is enclosed in a gas cabinet or without limit where both gases are enclosed in gas cabinets.
- Compressed gas containers, cylinders and tanks shall be kept a minimum of 10 feet from combustible waste, vegetation and similar materials.
- Compressed gas containers, cylinders and tanks shall not be placed near elevators, unprotected platform ledges or other areas where compressed gas containers, cylinders or tanks could fall for distances exceeding one-half the height of the container, cylinder or tank.
- Compressed gas containers, cylinders and tanks, whether full or partially full, shall not be exposed to temperatures exceeding 125°F or sub-ambient temperatures, unless designed for use under these conditions.
- Compressed gas containers, cylinders and tanks shall not be exposed to corrosive chemicals or fumes that could damage containers, cylinders or tanks or valve-protective caps.

9. Compressed gas containers, cylinders and tanks shall not be placed where they could become part of an electrical circuit.

### **G. Leaks, Damage, and Corrosion**

1. Leaking, damaged or corroded gas containers, cylinders and tanks shall be removed from service.
2. To prevent bottom corrosion, containers, cylinders and tanks shall be protected from direct contact with soil or surfaces where water might accumulate.

### **H. Storage**

1. Cylinders, containers and tanks containing liquefied flammable gases and flammable gases in solution shall be positioned in the upright position.
2. Containers with a capacity of 1.3 gallons or less shall be permitted to be stored in a horizontal position.
3. Cylinders, except nominal 0.5 kg (11b) propane cylinders made for consumer use that are not necessary for current laboratory requirements shall be stored outside the laboratory unit in accordance with NFPA 55.
4. Cylinders not “in use” shall not be stored in the laboratory unit.
5. Inflatable equipment, devices or balloons shall only be pressurized or filled with compressed air or inert gases.
6. Compressed Gases used for welding must meet the following storage criteria or the “24-hour” rule applies:
  - a. No more than a single acetylene cylinder and a single oxygen cylinder are stored on a cylinder cart. The cylinder cart must be specifically designed to hold/carry acetylene and oxygen cylinders in the upright position. The cylinders must be securely held to the cart (such as by straps, chains, or other securing device).
  - b. The cart is on a firm, level surface.
  - c. The cart is not in an area where there is a reasonably foreseeable risk of being struck by vehicles, equipment, or materials (such as in a pathway for vehicles on a construction site).
  - d. Both cylinders either have valves closed with protection caps on or are connected to a properly functioning regulator.

### **I. Handling**

1. Containers, cylinders and tanks shall be moved using an approved method.
2. Where containers, cylinders or tanks are moved by a hand cart, hand truck or other mobile device, such items shall be designed for the secure movement of containers, cylinders or tanks.
3. Ropes, chains and slings shall not be used to suspend compressed gas containers, cylinders or tanks, unless provisions have been made at the time of manufacture on the container, cylinder or tank for appropriate lifting attachments, such as lugs.

## **VI. Specific Types of Gases**

### **A. Corrosive Gases**

1. The outdoor storage of corrosive gases shall not be within 20 feet of buildings, lot lines, streets, alleys, public ways or means of egress.
2. A 2 hour fire barrier wall without openings or penetrations and extending not less than 30 inches above and to the sides of the storage or use area, shall be permitted in lieu of the 20 foot distance.

3. The fire barrier wall shall be either an independent structure or the exterior wall of the building adjacent to the storage or use area.
4. The 2 hour fire barrier shall be located at least 5 feet from any exposure.
5. The 2 hour fire barrier shall not have more than two sides at approximately 90 degree directions or not more than 3 sides with connecting angles of approximately 135 degrees.
6. The indoor use of corrosive gases shall be provided with a gas cabinet, exhausted enclosure or gas room.
7. The exhaust from gas cabinets, exhausted enclosures and gas rooms shall be directed to treatment systems designed to process the accidental release of gas.
8. Gas treatment is not required if there is a gas detection system with sensing intervals not exceeding 5 minutes and fail safe automatic closing valves immediately adjacent to and downstream of the active container, cylinder or tank.
9. The fail safe valve shall close when the gas is detected at the permissible exposure limit, short term exposure limit or ceiling limit.

**B. Flammable Gases**

1. The outdoor storage or use of flammable compressed gas shall be in accordance with **Table Three**.

**Table Three: Distances to Exposures for Flammable Gases**

Maximum Amount per Storage Area	Minimum Distances to Buildings, Streets or Public Ways	Minimum Distances Between Storage Areas
<4,225 ft <sup>3</sup>	5 Feet	5 Feet
4,226 – 21,125 ft <sup>3</sup>	10 Feet	10 Feet
21,126 – 50,700 ft <sup>3</sup>	15 Feet	10 Feet
50,701-84,500 ft <sup>3</sup>	20 Feet	10 Feet
>84,501 ft <sup>3</sup>	25 Feet	20 Feet

Note: The minimum required distances does not apply where fire barriers without openings or penetrations having a minimum fire-resistive rating of 2 hours interrupt the line of sight between the storage and the exposure. The configuration of the fire barriers shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

2. The minimum required distances shall be reduced to 5 feet where protective structures having a minimum fire resistance rating of 2 hours interrupt the line of site between the container and the exposure. The protective structure shall be at least 5 feet from the storage or use area perimeter.
3. The configuration of the protective structure shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.
4. The storage and use of flammable compressed gases shall not be located within 50 feet of air intakes.
5. Static producing equipment shall be grounded.
6. Signs shall be posted in area containing flammable gases communicating that smoking or the use of open flame or both is prohibited within 25 feet of the use or storage perimeter.

**C. Oxidizing Gases**

1. The outdoor storage or use of oxidizing compressed gases shall be in accordance with **Table Four**.

**Table Four: Distances to Exposures for Oxidizing Gases**

Quantity of Gas Stored	Minimum Distances to Buildings, Streets or Public Ways	Minimum Distances Between Storage Areas
0-50,000 ft <sup>3</sup>	5 Feet	5 Feet
50,001 – 100,000 ft <sup>3</sup>	10 Feet	10 Feet
>100,000 ft <sup>3</sup>	15 Feet	15 Feet

- The distances in **Table Four** shall not apply where protective structures having a minimum fire resistance of 2 hours interrupt the line of sight between the container and the exposure.
- The protective structure shall be at least 5 feet from the storage or use area perimeter.
- The configuration of the protective structure shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

**D. Pyrophoric Gases**

- The outdoor storage or use of pyrophoric compressed gases shall be in accordance with **Table Five**.

**Table Five: Distances to Exposures for Pyrophoric Gases**

Minimum Distances to Buildings on the Same Property						
Maximum Amount per Area	Minimum Distance Between Storage Areas	Minimum Distance to Property Lines	Minimum Distance to Public Ways	Nonrated or Openings Within 25 Feet	2 Hour and No Openings Within 25 Feet	4 Hour and No Openings Within 25 Feet
250 ft <sup>3</sup>	5 Feet	25 Feet	5 Feet	5 Feet	0 Feet	0 Feet
> 250 - 2,500 ft <sup>3</sup>	10 Feet	50 Feet	10 Feet	10 Feet	5 Feet	0 Feet
> 2,500 - 7,500 ft <sup>3</sup>	20 Feet	100 Feet	20 Feet	20 Feet	10 Feet	0 Feet

- The distances in **Table Five** shall not apply where protective structures having a minimum fire resistance of 2 hours interrupt the line of sight between the container and the exposure.
- The protective structure shall be at least 5 feet from the storage or use area perimeter.
- The configuration of the protective structure shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

**E. Toxic and Highly Toxic Gases**

- The indoor storage or use of highly toxic or toxic gases shall be provided with a gas cabinet, exhausted enclosure or gas room. Gas cabinets, exhausted enclosures and gas rooms containing toxic or highly toxic gases shall be provided with exhaust ventilation. All ventilation exhaust shall be directed to a treatment system designed to process accidental releases of gas.
- The outdoor storage or use of toxic or highly toxic compressed gases shall not be within 75 feet of lot lines, streets, alleys, public ways, means of egress or buildings.
- Storage and use of toxic and highly toxic compressed gases shall not be located within 75 feet of air intakes.

4. While in storage treatment systems are not required for toxic and highly toxic gases if the valve outlets are equipped with plugs or caps that are rated for the container service pressure and the handwheels are secured to prevent movement.
5. While in use treatment systems are not required if toxic gases and only toxic gases if a gas sensing system is in place with a sensing interval that does not exceed 5 minutes and there is an automatic closing fail safe valve located immediately adjacent to and downstream of the active container, cylinder or tank. The gas detection system shall monitor the exhaust system at the point of discharge from the gas cabinet, exhausted enclosure or gas room.
6. The fail safe valve shall close when gas is detected at the permissible exposure limit, short term exposure limit or ceiling limit by the detection system.

## F. Cryogenic Fluids

1. Containers employed for the storage or use of cryogenic fluids shall be designed, fabricated, tested, marked and maintained in accordance with the United States Department of Transportation regulations: *Transportation of Dangerous Goods Regulations*; the American Society of Mechanical Engineers, *Boiler and Pressure Vessel Code, Rules for the Construction of Unfired Pressure Vessels*.
2. Portable cryogenic containers shall be marked in accordance with CGA C-7, *Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers*.
3. All DOT-4L Liquid cylinders shall have product identification from all directions with a minimum of 2 inch high letters.
4. Visible hazard identification signs shall be provided in accordance with NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, at entrances to buildings or areas in which cryogenics fluids are stored, handled or used.
5. Portable containers subject to shifting or upset shall be secured. Nesting shall be permitted as a means of securing portable containers.
6. Areas where cryogenic fluids are stored or dispensed, shall be provided with mechanical ventilation or natural ventilation. If natural ventilation is provided, it must be demonstrated that it is acceptable for the cryogenic fluid being stored or used.
7. Where mechanical ventilation is provided, the system shall be operational during the time the building or space is occupied.
8. Mechanical ventilation shall be at a rate not less than 1 ft<sup>3</sup>/min/ft<sup>2</sup> of floor area over the area of storage or use. The system shall operate continuously unless an alternate design is approved by the Authority Having Jurisdiction.
9. Where mechanical ventilation is provided, a manual shutoff switch shall be provided outside of the room in a position adjacent to the principal access door to the room in an approved location. The switch shall be the break-glass or equivalent type and shall be labeled as follows: **Warning: Ventilation System Emergency Shutoff.**

## G. Hydrogen Gas

1. No more than 400 ft<sup>3</sup> of hydrogen per control area can be stored or used at a time indoors.
2. Valves, gauges, regulators and other accessories used for hydrogen shall be specified for hydrogen service by the manufacturer or the hydrogen supplier.
3. Cabinets or enclosures containing hydrogen control or operating equipment shall be ventilated to minimize the accumulation of hydrogen.

4. Hazard identification shall be placed at all entrances to locations where hydrogen is stored, used or handled, in accordance with NFPA 704, *Standard for the Identification of the Hazards for Materials for Emergency Response*.
5. Further, the area shall be permanently posted as follows: **Warning: Hydrogen Flammable Gas No Smoking No Open Flames**
6. All containers, cylinders and tanks of hydrogen stored or used within 50 feet of all classes of flammable and combustible liquids shall be located at a higher elevation than such liquids as to prevent the accidental accumulation of these liquids under the system.
7. Hydrogen containers, cylinders and tanks shall be separated from other incompatible materials.
8. Hydrogen containers, cylinders and tanks shall be kept a minimum distance of 25 feet from open flames as well other ignition sources.
9. Hydrogen containers, cylinders and tanks shall be kept a minimum of 50 feet from air intakes, air conditioning equipment and air compressors.
10. When placing single container, cylinder or tank of hydrogen in a laboratory, room or other indoor area for use or storage the maximum distance possible between other flammable and oxidizing compressed gases shall be used.

## **VII. References and Additional Resources**

### **A. National Fire Protection Association (NFPA)**

1. NFPA 45
2. NFPA 55

### **B. OSHA Standards for General Industry 29 CFR 1910**

1. [29 CFR 1910.101](#) Compressed Gases (General Requirements)
2. [29 CFR 1910.102](#) Acetylene
3. [29 CFR 1910.103](#) Hydrogen
4. [29 CFR 1910.104](#) Oxygen
5. [29 CFR 1910.105](#) Nitrous Oxide
6. [29 CFR 1910.253](#) Oxygen-fuel Gas Welding and Cutting
7. [29 CFR 1926.350](#) Gas Welding and Cutting

### **C. Compressed Gas Association**

1. [CGA Pamphlet P-1](#) Safe Handling of Compressed Gases

**For additional information concerning the proper storage or use of compressed gases or cryogenic fluids please contact Environmental Health and Safety at 304-293-5792.**