CHAPTER 20 - COMPRESSED, LIQUEFIED AND CRYOGENIC GASES

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A. INTRODUCTION

1. The properties of compressed gases, liquefied compressed gases and cryogenic fluids make them extremely useful. However, due to potential hazards of stored energy and chemical reactivity, the safety practices in their handling, use, storage, and transportation is of prime importance. The purpose of this Chapter is to provide fire, safety and employee health information as they relate to these gases and fluids.
2. It is the policy of the Smithsonian Institution (SI) that the handling, storage, and use of all compressed gas cylinders shall conform to the following regulations:
   a. Occupational Safety and Health Administration (OSHA), 29 Code of Federal Regulations (CFR) standards: 29 CFR 1910.101 – Compressed Gases, General Requirements; 29 CFR 1910.102 – Acetylene; 29 CFR 1910.103 – Hydrogen; 29 CFR 1910.104 – Oxygen; 29 CFR 1910.105 – Nitrous Oxide, Click Here and Storage and handling of liquefied petroleum gases - 1910.110.
   b. National Fire Protection Standards (NFPA) see references.
   c. Compressed Gas Association (CPA) pamphlets.
   d. The International Fire Code (IFC).
   e. American National Standards Institute (ANSI).
3. Refer to Chapter 14, "Hot Work Management and Permit System", of this *Manual*, for information on hot work (e.g., welding, cutting, and brazing) and Chapter 36, " Fire Protection", of this *Manual*, for information on flammable/combustible compressed gases.
4. Medical oxygen will not be addressed in this Chapter.

B. CHAPTER SPECIFIC ROLES AND RESPONSIBILITIES

1. Safety Coordinators
   a. Identify, with the assistance of supervisors and the Office of Safety, Health and Environmental Management (OSHEM), areas that have compressed gases and cryogenics. Inspect these areas during their annual physical self-inspection and evaluate compliance with this Chapter in their annual self-assessment program.
   b. Coordinate any training on specific gases through the manufacturer/supplier or OSHEM, if needed.

2. Supervisors
    a. Ensure that they are knowledgeable about any compressed gas and cryogenics in their workplace and the applicable OSHA, NFPA or CPA Pamphlets.
    b. Determine that compressed gas cylinders under their control are in a safe condition to the extent that this can be determined by visual inspection.
    c. Ensure employees receive training on this Chapter and for specific gases or cryogenics, and understand the hazards and safe work practices involved before working with them.
    d. Provide appropriate personal protective equipment (PPE) to employees working with compressed gases or cryogenics.
    e. Review with employees the causes of, future prevention of, and lessons-learned from any accident or near misses that have occurred involving compressed gases and/or cryogens.
3. Employees
    a. Attend required safety training on compressed gases and cryogenics and apply these lessons and safe work practices to their assigned job tasks.
    b. Provide, research and lead discussions on safety topics of compressed gases or cryogenics pertinent to your job.
    c. Wear appropriate personal protective equipment.

C. DEFINITIONS

1. Compressed Gas – Any material or mixture having, when in its container, an absolute pressure exceeding 40 psia (an absolute pressure of 276kPa) or 70 degree F (21.1 degree C or, regardless of the pressure at 70 degree F(21.1 degree C, having an absolute pressure exceeding 104 psia (an absolute pressure of 717 kPa) at 130 degree F(54.4 degree C).
2. Compressed Natural Gas (CNG) – Mixtures of hydrocarbon gases and vapors consisting principally of methane in gaseous form that has been compressed for use as a vehicular fuel.
3. Cryogenic Fluid – A substance that exists only in the vapor phase above minus 73 degree C (minus 99 degree F) at one atmosphere pressure and that is handled, stored, and used in the liquid state at temperatures at or below minus 73 degree C (minus 99 degree F) while at any pressure.
4. Liquefied Natural Gas (LNG) – A fluid in the cryogenic liquid state that is composed predominantly of methane.
5. Liquefied Petroleum Gas (LP Gas) – Any material having a vapor pressure not exceeding that allowed for commercial propane that is composed predominantly of the following hydrocarbons, either by themselves or as

mixtures: propane, propylene, butant (normal butane or isobutene), and butylenes.

6. Pressure Relief Valve – A device designed to open to prevent a rise of internal pressure in excess of a specified value due to emergency or abnormal conditions.
7. Storage - Oxygen and gas cylinder storage in “general industry” workplaces are not considered to be storage when they are either “in use” or “connected for use,” per 29 CFR 1910.253. However, in the “construction industry” a cylinder would be considered to be in use only when gas is being drawn or it is reasonably anticipated that gas will be drawn from the cylinder within 24 hours, per 29 CFR 1926.350.

D. COMPRESSED AND LIQUEFIED GASES

1. Hazard Identification. Depending on the particular compressed gas, there is a potential for simultaneous exposure to either chemical or physical hazards, or a combination of both types of hazards.
   a. Chemical hazards include corrosive and poisonous compressed gases. Even high concentrations of an “inert gas” such as nitrogen may cause asphyxiation.
   b. Physical hazards include flammable/combustible or explosive compressed gases. A flash point that is lower than room temperature and compounded by a high rate of diffusion presents a danger of fire or explosion. Since compressed gases are stored in heavy, highly pressurized metal containers, the large amount of potential energy resulting from the compression of a gas makes the cylinder a potential rocket or fragmentation bomb.
2. Identification/Labeling - General Requirements
   a. The contents of all compressed gas cylinders must be clearly identified. The contents may be stenciled or stamped on the cylinder, or a label may be used. The markings shall be located on the shoulder of the cylinder. This method conforms to the MIL-STD 1411A “Inspection and Maintenance of Compressed Gas Cylinders (2002)” and DOT regulations per 29 CFR 1910.6.
   b. Cylinders that are not legibly marked with its contents shall not be accepted from the vendor/delivery company. Therefore, a visual inspection should be performed on all incoming cylinders; Attachment 1, Receiving Cylinder checklist can be used for this inspection. If the labeling on an SI cylinder becomes illegible to the point that the contents cannot be identified, the cylinder shall be marked “contents unknown.” Contact your supervisor and Safety Coordinator for assistance in arranging for the unknown cylinder to be returned to the manufacturer through the vendor/delivery company.

c. The color of the cylinder MUST NEVER be relied on for identification. Color-coding is not reliable because cylinder colors may vary by supplier and their caps are interchangeable.

d. All facility gas lines leading from a compressed gas supply shall be clearly labeled to identify the gas, the area served, and the telephone number of the emergency point of contact for the facility.

e. Warning signs shall be conspicuously posted in areas where flammable compressed gases are stored. The warning sign shall identify the compressed gas and the appropriate warning(s)/precaution(s). For example: "HYDROGEN – FLAMMABLE COMPRESSED GAS – NO SMOKING – NO OPEN FLAMES."

3. Use, Handling, and Storage – General Requirements

a. Storage

(1) Read labels and Material Safety Data Sheets (MSDSs) before using, handling, and storing compressed gases.

(2) Compressed gas cylinders must be secured (chained in place, stored in a holding cage or racks, or have a non-tip base attached) to prevent tipping over. The cylinders (empty or full) shall also be stored in an upright position unless designed specifically for use in a horizontal position, and be stored away from elevators, stairs or high traffic areas.

(3) Valve caps or collars shall protect containers, cylinder and tank valves from physical damage. Where compressed gas containers, cylinders or tanks are designed to accept valve protective caps, the caps shall be kept on the container, cylinder or tank at all times, except when being processed or connected for use.

(4) All portable cylinders used for shipment and storage of compressed gas cylinders shall be constructed and maintained in accordance with the U.S. Department of Transportation (DOT) regulations, 49 CFR Parts 171-179.

(5) When gases of different types are stored at the same location, cylinders shall be grouped by types of gases. Groups shall be arranged to take into account the gases contained; per NFPA 55, flammable gases shall not be stored near oxidizing gases.

(6) Oxygen cylinders, full or empty, shall not be stored in the same vicinity as flammables and combustibles. The proper storage for oxygen cylinders requires that a minimum of 20 feet be maintained between flammable gas cylinders and oxygen cylinders or the storage areas be separated, at a minimum, by a firewall 5 foot high with a fire rating of ½ hour. Greasy and oily materials shall never be stored around oxygen cylinders.

(7) Cylinders containing flammable gases such as hydrogen or acetylene must not be stored in close proximity to open flames, areas where

electrical sparks are generated, or where other sources of ignition may be present.

(8) Cylinders containing acetylene shall never be stored on their side.

(9) Cylinders shall not be stored in unventilated enclosures such as lockers or cupboards.

(10) If cylinders are stored inside a building, they must be stored at least 20 feet from flammable liquids and easily ignitable materials (e.g., wood paper, oil, grease, etc.) per NFPA 55.

(11) If cylinders are stored in separate rooms/buildings, the rooms/buildings shall be well ventilated. Indoor storage areas shall not be located near boilers, steam/hot water pipes or excessive temperatures, or other sources of ignition. They are not to be exposed to physical damage, or tampering by unauthorized persons.

(12) Outdoor storage areas must have proper drainage and shall be protected from direct sunlight.

(13) Cylinders shall not be stored in basements, pit, or similar location where heavier-than-air gas might collect.

(14) Bulk storage of cylinders in a laboratory is prohibited.

(15) Empty and full cylinders shall be stored separately.

b. Equipment – Valves, Connections, and Regulators

(1) Standard cylinder-valve outlet connections have been devised by the Compressed Gas Association (CGA) to prevent mixing of incompatible gases. The outlet threads used vary in diameter and may be internal, external, right-handed, and/or left-handed.

(2) Compressed gas cylinders shall be equipped with connections complying with the CGA-V-1 “Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections (2005)”.

(3) Only CGA standard combinations of valves and fittings shall be used in compressed gas installations. Examine the threads on cylinder valves, regulators, and other fittings to ensure they correspond and are undamaged.

(4) Cylinders shall be placed with the valve accessible at all times.

(5) The main cylinder valve shall be closed when it is not in use. It shall never be left open when the equipment is unattended or not in operation. Closing the cylinder valve is important to maintain safety when the cylinder is under pressure and to prevent the corrosion and contamination resulting from diffusion of air and moisture into an empty cylinder.

(6) Cylinders are equipped with either a hand wheel or stem valve:

(a) For cylinders equipped with a stem valve, keep the valve spindle key on the stem while the cylinder is in service.

(b) Only wrenches or tools provided by the cylinder supplier shall be used to open or close a valve.

(c) Pliers shall never be used to open a cylinder valve.

(7) Do not apply oil or grease to fittings or regulators.

(8) Regulators are gas-specific and are not necessarily interchangeable. Always make sure the regulator and valve fittings are compatible.

c. Leaking Cylinders

(1) Leaking compressed gas cylinders shall be immediately reported to your supervisor and facility Safety Coordinator. Depending on the type of gas in the cylinder, the work area may need to be evacuated. The Safety Coordinator will use the MSDS to evaluate the hazard. Contact the vendor as soon as possible.

(2) Never attempt to repair a leaking cylinder or valve.

(3) Leaking, damaged, or corroded compressed gas containers, cylinders and tanks shall be removed from service in an approved manner and repaired to a serviceable condition, per NFPA 55.

d. How to Use

(1) Open cylinder valves slowly.

(2) Open oxygen cylinder valves all the way. Open up the oxygen cylinder valve stem just a crack. Once the needle on the high pressure gauge has stopped, open up the valve all the way, which will back seat the valve.

(3) When opening the valve on a cylinder containing an irritating or toxic gas, position the cylinder with the valve pointing away from you and warn any other employees working nearby.

(4) Do not empty cylinders to a pressure lower than 172 kPa (25 psi per square inch); the residual contents may become contaminated if the valve is left open.

(5) When work involving the compressed gas is completed, the cylinder valve must be turned to zero “0” and the lines bled.

(6) Welding or cutting:

(a) When welding or cutting is stopped for an hour or longer:

i. Close the cylinder or manifold valve.

ii. Open the torch valves momentarily to bleed the lines of gas pressure.

iii. Release the regulator pressure adjusting screws.

(b) When the operation has stopped for a few minutes, the torch valves alone may be closed.

(c) Before turning the cylinder or manifold valve to the open position to resume work, double-check the regulator to ensure that the pressure is still released from the regulator. If not, release the pressure before opening the cylinder or manifold valves.

4. Transportation of Cylinders

   a. Before moving a cylinder, all valves shall be closed, the system bled, the regulator removed, and the valve cap replaced. If the cylinder is empty, it shall be clearly marked as "empty" and returned to the empty storage area for pick-up by the supplier.

   b. Do not subject cylinders to rough handling or abuse. They are heavy and could cause injury if not handled or stored properly. Misuse of cylinders may weaken the cylinder and render it unfit for further use. Breaking off the stem/valve could transform the cylinder into a projectile, having sufficient thrust to drive it through masonry walls.

   c. To protect the valve during transportation, regulators shall be removed, the valve cap shall be screwed on, hand-tight, and remain on until the cylinder is in place and ready to use. If the cylinders are in a specially designed cart that assures protection from damage, the regulators do not necessarily have to be removed.

   d. Do not roll or drag cylinders.

   e. Cylinders shall not be lifted by the valve protection cap.

   f. Cylinders, empty or full, shall not be used as rollers or supports.

   g. Strap cylinders into a properly designed wheeled cart.

   h. Consult the compressed gas cylinder supplier if there is any doubt about the proper handling and transportation procedures.

5. Transfer of compressed gases are outlined in NFPA 55. Inflatable equipment, devices, or balloons shall only be pressurized or filled with compressed air or inert gases per NFPA 55.

E. CRYOGENICS

1. Cryogenic liquids are gases that have been transformed into extremely cold refrigerated liquids that are stored at temperatures below minus 103 degree F (minus 90 degree C). Examples of gases commonly handled as cryogenic liquids include oxygen, fluorine, nitrogen, argon, neon, krypton, xenon, hydrogen, methane (natural gas), and helium. Liquefied natural gas (LNG) and/or liquid methane and carbon monoxide are also handled as cryogenic liquids. The storage or use of cryogenics shall be in accordance with this

Chapter, NFPA 55, and CGA P-12 “Safe Handling of Cryogenic Liquids” pamphlet.

2. Hazards. There are four types of hazards related to the use of cryogenic liquids: 1) flammability, 2) high pressure gas, 3) burns from the material, and 4) asphyxiation.

   a. The flammability hazard is clear when gases such as hydrogen, methane, and acetylene are considered. However, the fire hazard may be greatly increased when gases normally thought to be non-flammable are used. The presence of oxygen will greatly increase the flammability of ordinary combustibles, and may even cause some noncombustible materials like carbon steel to burn readily under the right conditions.

   b. The high-pressure gas hazard is always present when cryogenic fluids are used or stored. Since the liquefied gases are usually stored at or near their boiling point, there is always some gas present in the container. The large expansion ratio from liquid to gas provides a source for the build-up of high pressures due to the evaporation of the liquid. The rate of evaporation will vary, depending on the characteristics of the fluid, container design, insulating materials, and environmental conditions of the atmosphere.

   c. Exposure of personnel to the hazards of the material must be avoided; very brief skin contact with fluids or materials at cryogenic temperatures is capable of causing burns similar to thermal burns from high temperature contacts. Prolonged contact with these temperatures will cause embrittlement of exposed members because of the high water content of the human body. The eyes are especially vulnerable to this type of exposure.

   d. While a number of the gases in the cryogenic range are not toxic, they are all capable of causing asphyxiation by displacing the air necessary to support life. Even oxygen may have harmful physiological effects if prolonged breathing of pure oxygen takes place.

3. Use, Handling, and Storage

   a. Equipment:

      (1) Materials must be carefully selected for cryogenic service because of the drastic changes in the properties of materials when they are exposed to extreme low temperatures. The American Society of Mechanical Engineers' Boiler and Pressure Vessel Code, Section VIII Unfired Pressure Vessels may be used as a specific guide to the selection of materials to be used in cryogenic service.

      (2) Piping or transfer lines shall be constructed so that it is not possible for fluids to become trapped between valves or closed sections of the line. Evaporation of the liquid in a section of line may result in pressure build-up and explosion. If it is not possible to empty all lines, they must be equipped with safety relief valves and rupture discs. When venting

storage containers and lines, consideration must be given to the properties of the gas being vented. Venting shall be to an outside location to prevent an accumulation of flammable, toxic or inert gas in the work area.

(3) Cryogenic liquid equipment shall be kept clean, and contamination avoided, which may create a hazardous condition upon contact with the cryogenic liquids used – especially when working with liquid or gaseous oxygen.

b. Use and Handling

(1) Cryogenic fluids are to be used in equipment and systems that are free from contaminating materials that could create a hazardous condition upon contact with the cryogen.

(2) Mixtures of gases or fluids shall be strictly controlled to prevent the formation of flammable or explosive mixtures. When flammable gases are being used, potential ignition sources shall be strictly controlled. Work areas/laboratories shall be monitored so that personnel may be warned when a dangerous condition is developing. When practical, the cryogenic liquid system shall sound a warning alarm and automatically shut down.

(3) Storage

(a) All cryogenic storage vessels must include an allowance for that portion which will be in the gaseous state and shall be chosen to withstand the weights and pressures of the materials used, and shall have adequate venting to prevent pressure buildup.

(b) Store cryogenic liquids in a well-insulated container designed to minimize loss of product due to boil-off. The most common container for cryogenic fluids is a double-walled, evacuated container known as a Dewar flask, of either metal or glass. Tape exposed glass portions of the container to minimize a flying glass hazard if the container breaks or implodes. Metal containers are generally used for larger quantities of cryogenic fluids and usually have a capacity of 10 to 100 liters (2.6 to 26 gallons). These containers have double-walled evacuated construction, and usually contain some adsorbent material in the evacuated space. Both the metal and glass Dewars shall be kept covered with a loose-fitting cap to prevent air or moisture from entering the container, and to allow built-up pressure to escape.

(c) Cryogenic fluids with boiling point below that of liquid nitrogen (particularly liquid helium and hydrogen) require specially constructed and insulated containers to prevent rapid loss of product from evaporation.

(d) Chemical reactivity between the fluid or gas and the storage containers and equipment must be studied. Wood or asphalt

saturated with oxygen has been known to literally explode when subjected to mechanical shock. When properties of materials that are being considered for cryogenic uses are unknown, or not to be found in the known guides, experimental evaluation should be performed before the materials are used in the system.

F. SPECIFIC GASES

1. Corrosive Gases –

   Corrosive gases attack human tissue and personnel handling and using corrosive gases must have personal protective equipment available for the particular gas to be used. Examples of acid gases include boron trichloride, chlorine, dichlorosilane, hydrogen bromide, hydrogen chloride (anhygrous), hydrogen fluoride, and sulfur dioxide. Examples of alkali gases include ammonia, monomethylamine, dimethylamine and trimethylamine. The storage or use of corrosive compressed gases shall be in accordance to NFPA 55.

2. Flammable Gases –

   Flammable gases are defined by the Department of Transportation (DOT) as those that when mixed with air are flammable in concentrations of 13 percent or less by volume of air. Examples of flammable gases include acetylene, butadiene, carbon monoxide, ethane, ethylene, hydrogen, hydrogen sulfide, the liquefied petroleum gases (i.e., butane, isobutene, propane, and propylene), methane, methylacetylene-propadiene, methyl chloride, silane, and vinyl chloride. The storage or use of flammable gases shall be in accordance to NFPA 55.

   a. Acetylene – Handling, storage and utilization of acetylene in cylinders shall be in accordance with CGA G-1”Acetylene (2003)” pamphlet.

   b. Fuel-Gas cylinders stored inside a building, except those in actual use or attached ready for use, shall be limited to a total gas capacity of 2,000 cubic feet or 300 lbs of liquefied petroleum gas.

   c. Liquefied Petroleum Gas (LPG)

(1) General

   (a) Liquefied petroleum gas (LPG), LP-gas, and propane shall be synonymous.

   (b) All propane tanks shall be installed in accordance with OSHA Standard 29 CFR 1910.110, “Storage and Handling of Liquefied Petroleum Gases,” National Fire Protection Association (NFPA) 58, “Standard for Storage and Handling of Liquefied Petroleum Gases,” and, where applicable, NFPA 54 and ANSI Standard Z233.1-2006, “Natural Fuel Gas Code.”

   (c) Cylinders shall be marked as provided in the regulations, rules, or code under which they are fabricated.

(d) Where LP-Gas and one or more other compressed gases are to be stored or used in the same area, the cylinders shall be marked with a minimum of 4 inch size letters that state “Flammable” and either “LPG”, “LP-GAS”, “Propane”, or “Butane”, or shall be marked in accordance with the requirements of MIL-STD 1411A “Inspection and Maintenance of Compressed Gas Cylinders (2002)” and 49 CFR, “Transportation.

(e) Warning signs shall be conspicuously posted on the outside of the fence in areas where propane is stored. The warning sign shall identify the gas and the appropriate warnings/precautions. For example: “PROPANE – FLAMMABLE – NO SMOKING WITHIN 30 FEET – NO OPEN LIGHT OR OPEN FLAMES”.

(f) The amount of LP gas in containers for research and experimental use shall be limited to the smallest practical quantity.

(g) Lighting shall be provided to adequately illuminate the storage tanks, the control valves, and the safety equipment.

(2) Equipment

(a) Pumps, piping, hoses, and other attachments shall meet OSHA and NFPA 58 requirements.

(b) Piping, pipe and tubing fittings, and valves used to supply utilization equipment within the scope of NFPA 54, National Fuel Gas Code, shall comply with that code.

(c) Cylinders shall be equipped with pressure relief valves as required by DOT regulations.

(d) Valves, manual shut-offs, check valves, and relief valves shall meet NFPA 58 requirements.

(e) Valves, regulators, gauges and other container appurtenances shall be protected against physical damage.

(f) All regulators for outdoor installations shall be designed, installed, or protected so their operation will not be affected by the elements (freezing rain, sleet, snow, ice, mud, or debris).

(3) Location

(a) Containers shall meet DOT specifications, and shall only be located outside of buildings except as identified in 29 CFR 1910.110, which includes portable use, LP-gas fueled stationary or portable engines, LP-gas fueled industrial trucks, and LP fueled vehicles.

(b) Containers shall be located aboveground, unless the container is designed for underground installation.

(c) Cylinders shall be installed on a firm foundation, not be in contact with the soil or water, and be protected from vehicular damage, and free of rust.

(d) The container and all associated accessories shall be enclosed by a minimum 6-foot high industrial-type fence. A minimum of 3-feet of clearance shall be maintained between the container and the fence.

(e) Readily ignitable materials such as weeds and long dry grass shall be removed within 10 feet of any container.

(4) Fire Safety. Per powered industrial trucks. - 1910.178 the storage and handling of LPG shall be in accordance with NFPA 58.

(5) Storage of Cylinders Awaiting Use, Resale, or Exchange:

(a)Cylinders in storage shall be located to minimize exposure to excessive temperature rises, physical damage, or tampering.

(b) Cylinders in storage having individual water capacity greater than 2.7 lb (l.l kg) {nominal l lb (0.45 kg) LP-Gas capacity} shall be positioned so that the pressure relief valve is in direct communication with the vapor space of the cylinder.

(c) Cylinders stored in buildings frequented by the public shall not be located near exits, stairways, or in areas normally used, or intended to be used, for the safe egress of occupants.

(d) Location of storage outside of buildings for cylinders awaiting use, resale, or part of a cylinder exchange point shall be located as follows:

(1) At least 5 feet from any doorway or opening in a building frequented by the public where occupants have at least two means of egress as defined by NFPA 101, Life Safety Code.

(2) At least 10 feet from any doorway or opening in a building or sections of a building that has only one means of egress.

(3) At least 20 feet from any automotive service station fuel dispenser.

(e) If empty cylinders that have been in LP-Gas services are stored indoors, they shall be considered as full cylinders for the purposes of determining the maximum quantities of LP-Gas permitted by NFPA 58.

(6) Industrial (and Forklift) Trucks Powered by LP-Gas:

(a) Cylinders shall be designed, constructed, or fitted for installation and filling in either the vertical or horizontal position, or if of the universal type, in either position.

(b) Industrial trucks with permanently mounted fuel containers shall be charged outdoors.

(c) Where cylinders are exchanged indoors, the fuel piping system shall be equipped to minimize the release of fuel when cylinders are exchanged, in accordance with either of the following:

(1) Using an approved quick-closing coupling in the fuel line,

(2) Closing the shutoff valve at the fuel cylinder and allowing the engine to run until the fuel in the line is exhausted.

(d) Where LP-Gas fueled industrial trucks are used in buildings or structure, the following shall apply:

(1) The number of fuel cylinders on such a truck shall not exceed two.

(2) Industrial trucks may only be used in buildings frequented by the public when no public or visitors are present.

(3) Trucks shall not be parked and left unattended in areas occupied by or frequented by the public. If left unattended in areas with approval, the cylinder shutoff valve shall be closed.

(4) In no case shall trucks be parked and left unattended in areas of excessive heat or near sources of ignition.

3. Oxygen and Oxidizing Gases – Oxygen and gas mixtures containing large quantities of oxygen react chemically with organic materials to produce heat. Examples include fluorine, chlorine, nitrogen trifluoride and nitrous oxide. The storage or use of oxidizing compressed gases shall be in accordance to NFPA 55.

4. Pyrophoric Gases – The storage or use of pyrophoric gases shall be in accordance to NFPA 55. Silane and silane mixtures shall be stored, used and handled in accordance with the provisions of CGA G-13 "Storage and Handling of Silane and Silane Mixtures (2006)".

5. Toxic and Highly Toxic Gases – The use of toxic cylinders shall only be under a laboratory hood, vented gas cabinet or with special safety-vented regulators connected to a local exhaust system for direct discharge to the atmosphere per Chapter 27, "Ventilation for Health Hazard Control", of this *Manual*. Examples include arsine, diborane, methyl bromide, nitric oxide, nitrogen dioxide, phosgene and phosphine. The storage or use of toxic and highly toxic gases shall be in accordance to NFPA 55.

G. PERSONAL PROTECTIVE EQUIPMENT (PPE)

1. Protective eyewear (e.g. safety glasses, goggles, face shields, etc.) shall be required when handling and using compressed gases, especially when disconnecting compressed gas regulators and lines. Refer to Chapter 17, "Personal Protective Equipment", of this *Manual*, for more information.

2. A face shield along with eyeglasses or goggles shall be required when handling and using an irritating gas.

3. When handling and using liquefied gases, never touch any non-insulated part of the cold equipment with any unprotected part of your body. The following PPE shall be worn:

a. Employee's eyes and faces shall be protected with safety glasses, goggles or face shields.

b. Clean, loose-fitting, non-porous gloves shall be worn together with a long-sleeved lab coat or jacket.

c. Avoid wearing open pockets, pants with cuffs, and other clothing that have places where a liquefied gas spill may collect.

H. TRAINING

1. Due to dangerous conditions that can result in the use of compressed gases and cryogenics, only personnel experienced and trained in the use of the compressed gases may handle them.
2. Job specific hazard awareness training on the compressed gas or cryogenic to be used will be provided by the supervisor to all persons prior to actually performing work.
3. Retraining, or refresher training, will occur when:
   a. Required by SI policy, required by regulation and/or detailed in specific operational Chapters of this *Manual*.
   b. A new hazardous process or material is introduced to the job site.
   c. Changes have occurred in applicable safety standards or workplace procedures that render the original training obsolete.
   d. An employee has demonstrated inadequacies in their understanding, knowledge, or skill in the use of equipment, tools, or recognized safety procedures of compressed gases or cryogenics.
   e. An employee has been reassigned to different duties, requiring different safety skill,

I. REFERENCES

1. Part 1910 CFR Occupational Safety and Health Administration, 29 CFR,1910.101 Compressed Gases (General Requirements),1910.102 Acetylene, 1910.103 Hydrogen, 1910.104 Oxygen and 1910.105 Nitrous Oxide.
2. OSHA Standard 29 CFR 1910.110, “Storage and Handling of Liquefied Petroleum Gases.”
3. OSHA Standard 29 CFR 1910.253 “Oxygen-Fuel Gas Welding and Cutting”.
4. National Fire Protection Association (NFPA) 30, “Flammable and Combustible Liquids Code.”
5. NFPA 45, “Standard on Fire Protection for Laboratories Using Chemicals.”
6. NFPA 51, “Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting and Allied Processes.”
7. NFPA 54/ANSI Z223.1-2006, “National Fuel Gas Code”.

8. NFPA 55, “Storage, use and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks.”
9. NFPA 58, “Standard for Storage and Handling of Liquefied Petroleum Gases.”
10. International Code Council’s, “International Fire Code”.
11. MIL-STD 101B “Color Code for Pipelines and Compressed Gas Cylinders”.
12. MIL-STD 1411A “Inspection and Maintenance of Compressed Gas Cylinders”.
13. CGA V-1 “Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections (2005)”.
14. CGA P-12 “Safe Handling of Cryogenic Liquids (2005)”.
15. U.S. Department of Transportation (DOT) regulations, 49 CFR Parts 171-179.

RECEIVING CYLINDERS

Personnel responsible for receiving cylinders and containers should perform an external inspection before moving them to the point of use or to the storage area.

Basic guidelines for performing this inspection are as follows:

BASIC INSPECTION GUIDELINES	YES	NO
Do the cylinder labels agree with what was ordered from the vendor? [1]		
Have the cylinders been thoroughly inspected for any obvious damage or leaks?		
Are the cylinder surfaces clean and free from defects such as cuts, gouges, burns and obvious dents?		
Do the cylinders stand stead and do not wobble?		
Do the cylinders with neck threads have a cap in place over the valve?		
Are the Cylinder valves not bent or damaged? [2]		
Have the cylinder valves been inspected for the presence of any dirt or oil which could not contaminate the gas?		

[1] Remember, the label is the only means of identifying the product in the cylinder. Never identify the product by the color of the cylinder.

[2] Remove the cap by hand.