PHOENIX FIRE CODE SUMMARY

COMPRESSED GAS SYSTEMS – CARBONATED BEVERAGE SYSTEMS
LIQUIFIED CARBON DIOXIDE SYSTEM

REFERENCE FIRE CODE SECTION

SCOPE OF THIS FIRE CODE SUMMARY
An explanation of the hazards of compressed gases, specifically liquefied carbon dioxide systems and City of Phoenix requirements for, installing, constructing and operations of liquefied carbon dioxide systems inside and outside of buildings.

REQUIRED PERMITS AND FEES

**All submittals must be done by a qualified design professional and include drawings, calculations, site plans and piping isometrics to show compliance with all City of Phoenix codes and this summary document. Submit all information to the City of Phoenix Planning and Development Department located at 200 W Washington St, 2nd Floor, paying all applicable construction, inspection and penalty fees, if applicable.

The following permits are required:

- **Compressed Gas System (PFC 105.7.7):** A construction permit is required to install or modify a compressed gas system. The fees to install are $540 for the plans review (4 hour minimum in excess of exempt amount quantities - 200 cu ft) and $540 for the inspection (4 hour minimum in excess of exempt amount quantities – 200 cu ft). The fees to install Compressed Gas Systems below the exempt amount quantities (200 cu ft) are $405 and $270 for the inspection. The fees to modify a compressed gas system are $405 for the plans review and $202.50 for the inspection. F155 – Compressed Gas System

- **Hazardous Materials above Permit Quantity:** If the quantity of hazardous materials in storage/use/handling exceeds the permit quantity (refer to PFC, Chapter 46—Fees, page 25), an additional operational permit is required. The permit quantity for Other Health Hazard Gases is 200 cu ft. A Hazardous Material Inventory Statement (HMIS) must be submitted to the Phoenix Fire Department Special Hazards Unit located at 150 S 12th St, Phoenix, AZ 85034.

- **Fire Alarm and Detection Systems and Related Equipment Permit (PFC 105.7.10):** A construction permit is required for installation or modification to fire alarm and detection systems and related equipment. Where required, a separate permit shall be obtained for supervisory off-premise fire alarm transmitters (Dialer). See PFC Chapter 46 for fees. F122, F129, or F175

- **Structural/Plumbing/Electrical/Mechanical Permit:** *Because CO2 is heavier than air mechanical ventilation is required. **See mechanical ventilation requirements below. For the installation of a compressed gas system a construction permit from Planning and Development Department is required for the review of mechanical ventilation, structural foundation, and electrical requirements mandated by the Phoenix Fire Code, Building Code and NFPA standards. Submit two sets of plans to Planning and Development Department located at 200 W Washington St, 2nd Floor. Each set should include a site plan, floor plan and mechanical/plumbing/electrical details as required. A copy of the Hazardous Material Inventory Statement (HMIS) should be included. Permit fee (s) are based on project, building, or area valuation. To obtain an accurate fee calculation, contact the Planning and Development Department.*

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Rev. 1/13/12
SPECIFIC GRAVITY: (Air = 1) at 70 degrees F (21.1 degrees C) and 1 atm: 1.52
LIQUID DENSITY: (saturated) at 70 degrees F (21.1 degrees C) and 1 atm: 47.6 lb/ft3 (762 kg/m3)
MOLECULAR WT: 44.01
MOLECULAR FORMULA: CO2

TOXICOLOGICAL INFORMATION
Carbon dioxide is an asphyxiant. It initially stimulates respiration and then causes respiratory depression. High concentrations result in narcosis. Symptoms in humans are as follows:

<table>
<thead>
<tr>
<th>EFFECT</th>
<th>CONCENTRATION</th>
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<tbody>
<tr>
<td>Breathing rate increases slightly.</td>
<td>1%</td>
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<tr>
<td>Breathing rate increases to 50% above normal level. Prolonged Exposure can cause headache, tiredness.</td>
<td>2%</td>
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<tr>
<td>Breathing increases to twice normal rate and becomes labored. Weak narcotic effect. Impaired hearing, headache, increased BP And pulse rate.</td>
<td>3%</td>
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<tr>
<td>Breathing increases to approximately four times normal rate, symptoms of intoxication become evident, and slight choking may be felt.</td>
<td>4 – 5%</td>
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<td>Characteristic sharp odor noticeable. Very labored breathing, headache, visual impairment, and ringing in the ears. Judgment may be impaired, followed within minutes by loss of consciousness.</td>
<td>5 – 10%</td>
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<tr>
<td>Unconsciousness occurs more rapidly above 10% level. Prolonged exposure to high concentrations may eventually result in death from Asphyxiation.</td>
<td>10 - 100%</td>
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HAZARD RATING SYSTEMS:
NFPA RATINGS:
- HEALTH = 3
- FLAMMABILITY = 0
- INSTABILITY = 0
- SPECIAL = SA (CGA recommends this to designate Simple Asphyxiant)

ADDITIONAL HAZARDS
Liquid Carbon Dioxide does not meet the fire code definition of a cryogen (boiling point for a cryogen is at -150 degrees F versus -109 degrees F triple point for CO2); but it is identical in hazard properties to other cryogenic liquids. A large volume of asphyxiant gas is released when Carbon Dioxide changes from liquid to gas (8.5 cubic feet per pound of liquid) which is similar to other cryogens (such as liquid nitrogen and liquid argon). Also carbon dioxide is colorless and odorless. In the event of a release, there may be no sensory warnings indicated before asphyxiation occurs. Additional hazards also include freeze burns due to extreme cold of the chemical. Additional Ventilation requirements inside buildings may be required, such as venting to an approved location outside of the building depending on the specific details of the Liquid Carbon Dioxide system installation.
SUMMARY OF FIRE CODE REQUIREMENTS

These guidelines shall apply to both new and existing buildings and shall detail the Phoenix Fire Department-Fire Prevention Division minimum requirements for compressed gas systems, specifically Liquid Carbon Dioxide Systems installations.

DEFINITIONS
The Phoenix Fire Code (chapter 30) defines COMPRESSED GAS a material or mixture of materials which:

1. is a gas at 68 F or less at 14.7 psia of pressure; and
2. has a boiling point of 68 F or less at 14.7 psia which is either liquefied or in solution, except those gases which have no other health-or physical –hazard properties are not considered to be compressed until the pressure in the packaging exceeds 41 psia of 68 F.

The states of compressed gas are categorized as follows:

1. Non liquid compressed gases are gases, other than those in solution, which are in a packaging under charged pressure and are entirely gaseous at a temperature of 68 F.
2. Liquefied compressed gases are gases that, in a packaging under the charged pressure, are partially liquid at a temperature of 68 F.
3. Compressed gases in solution are non liquefied gases that are dissolved in a solvent.
4. Compressed gas mixtures consist of a mixture of two or more compressed gases contained in a packaging, the hazard properties of which are represented by the properties of the mixture as a whole.

The Phoenix Fire Code (chapter 30) defines COMPRESSED GAS SYSTEM as an assembly of equipment designed to contain, distribute or transport compressed gases. It can consist of a compressed gas container or containers, reactors and appurtenances, including pumps, compressors and connecting piping and tubing.

The Phoenix Fire Code (chapter 32) defines CRYOGENIC FLUID as a fluid having a boiling point lower than -130 degrees F (-89.9 C) at 14.7 pounds per square inch atmosphere (psia) (an absolute pressure of 101.3kPa). The International Fire Code and Commentary (2006 ed.) states that if a fluid falls outside the criteria indicated above, it would likely be treated as a compressed gas and addressed within Chapter 30.

NFPA 55 (2010 ed.) defines a SMALL INSULATED LIQUID CARBON DIOXIDE SYSTEM as an assembly of equipment consisting of one or more insulated carbon dioxide containers, interconnecting piping, pressure regulators, and pressure relief devices. The capacity of individual containers is 1000 pounds of carbon dioxide gas or less.

PEL – Permissible Exposure Level; Permissible Exposure Levels of carbon dioxide vapors is 5,000 (PPM) parts per million.

PHOENIX FIRE CODE REQUIREMENTS: The following summarizes the requirements for the installation and modification of compressed gas systems contained in the Phoenix Fire Code (2006), Chapters 27 and 30, NFPA 55 (2010, provisions of Chapter 13 and Chapters 1 through 7 as applicable) and NFPA 72 (2010). The following summarizes the requirements for the construction, storage, use and handling of compressed gas systems (liquid carbon dioxide insulated systems).

Design and Construction
- Compressed gas systems shall be designed for the intended use and shall be designed by persons competent in such design. (NFPA 55 – 7.1.1.1)
- Installation of bulk compressed gas systems shall be supervised by personnel knowledgeable in the application of the standards for their construction and use. (NFPA 55 – 7.1.1.2)
Containers, cylinders, and tanks shall be designed, fabricated, tested, and marked (stamped) in accordance with regulations of DOT, Transport Canada (TC) Transportation of Dangerous Goods Regulations, or the ASME Boiler and Pressure Vessel Code, “Rules for the Construction of Unfired Pressure Vessels,” Section VIII. (NFPA 55 – 7.1.5.1)

Compressed gas containers, cylinders and tanks shall be designed, fabricated, tested, marked with the specifications of manufacture and maintained in accordance with regulation of DOT 49 CFR, Parts 100-178 or ASME Boiler and Pressure Vessel Code, Section VII. (PFC - 3003.2)

Stationary cylinders, containers, and tanks shall be provided with engineered supports of noncombustible material on noncombustible foundations. (NFPA 55 – 7.1.5.3)

Stationary pressure vessels shall be designed, constructed, and certified as being compliant with ASME Boiler and Pressure Vessel Code 2007, Section VIII, Divisions 1 or 2. An ASME U-1 report shall be provided to the fire department for any new pressure vessel installation. The fire department is authorized to require an ASME U-1 report for an installation of an existing pressure vessel being installed at a new location. (PFC – 2703.2.10.1)

When a stationary pressure vessel is repaired or is modified, an ASME R-1 report shall be made available to the fire department. Upon completion of the repairs or modifications to a pressure vessel, a nameplate indicating the nature of the work shall be affixed to the pressure vessel. The repair nameplate shall be affixed near the original nameplate. (PFC – 2703.2.10.2)

Compressed gas systems shall be suitable for the use intended and shall be designed by persons competent in such design. Compressed gas equipment, machinery and processes shall be listed or approved. (PFC – 3005.1)

Compressed gas system controls shall be designed to prevent materials from entering or leaving process or reaction systems at other than the intended time, rate or path. Automatic controls shall be designed to be fail safe. (PFC – 3005.2)

Equipment, machinery and required detection and alarm systems associated with the use, storage or handling of hazardous materials shall be listed or approved. (PFC – 2703.2.3)

Stationary pressure vessels designed for the storage or hazardous materials shall be in accordance with this section. When a stationary pressure vessel designed for the storage of hazardous materials is governed by another standard or section, the applicable requirements for the design and construction of the container and its appurtenances shall take precedence. (PFC – 2703.2.10)

Stationary pressure vessels shall be designed, constructed, and certified as being compliant with ASME Boiler and Pressure Vessel Code 2007, Section VIII, Divisions 1 or 2. An ASME U-1 report shall be provided to the fire department for any new pressure vessel installation. The fire department is authorized to require an ASME U-1 report for an installation of an existing pressure vessel being installed at a new location. (PFC – 2703.2.10.1)

 Liquids having a hazard ranking of 3 or 4 in accordance with NFPA 704 shall be transferred by one of the following methods:
1. From safety cans complying with UL 30.
2. Through an approved closed piping system.
3. From containers or tanks by an approved pump taking suction through an opening in the top of the container or tank.
4. From containers or tanks by gravity through an approved self-closing or automatic-closing valve when the container or tank and dispensing operations are provided with spill control and secondary containment in accordance with Section 2704.2. Highly toxic liquids shall not be dispensed by gravity from tanks.
5. Approved engineered liquid transfer systems. (PFC- 2705.1.10)

 Systems shall be suitable for the use intended and shall be designed by persons competent in such design. Controls shall be designed to prevent materials from entering or leaving the process or reaction systems at other than the intended time, rate or path. Where automatic controls are provided, they shall be designed to be fail safe. (PFC-2705.2.2.1)

Physical Protection/Security

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Rev. 1/13/12
Pressure relief devices shall be located to minimize tampering, damage, and obstruction to flow. (NFPA 55 – 13.1.1.1.1)

The inlet and outlet of the relief devices shall not be blocked by a valve or plug during normal operation. (NFPA 55 – 13.1.1.1.2)

Compressed gas containers, cylinders, tanks and systems shall be secured against accidental dislodgement and against access by unauthorized personnel. (PFC - 3003.5).

Areas used for the storage, use and handling of compressed gas containers, cylinders, tanks and systems shall be secured against unauthorized entry and safeguarded in an approved manner. (PFC - 3003.5.1)

Compressed gas containers, cylinders, tanks and systems which could be exposed to physical damage shall be protected. Guard posts or other approved means shall be provided to protect compressed gas containers, cylinders, tanks and systems indoors and outdoors from vehicular damage and shall comply with section 312 (Vehicle Impact Protection). (PFC - 3003.5.2)

Vehicle impact protection required by this code shall be provided by posts that comply with Section 312.2 (Vehicle Impact Protection-Posts) or by other approved physical barriers that comply with Section 312.3 (Vehicle Impact Protection-Other barriers). (PFC – 301.2)

Guard posts shall comply with all of the following requirements:
1. Constructed of steel not less than 4 inches (102 mm) in diameter and concrete filled.
2. Spaced not more than 4 feet (1219 mm) between posts on center.
3. Set not less than 3 feet (914 mm) deep in a concrete footing of not less than a 15-inch (381 mm) diameter.
4. Set with the top of the posts not less than 3 feet (914 mm) above ground.
5. Located not less than 3 feet (914 mm) from the protected object. (PFC – 312.2)

Physical barriers shall be a minimum of 36 inches (914 mm) in height and shall resist a force of 12,000 pounds (53 375 N) applied 36 inches (914 mm) above the adjacent ground surface. (PFC – 312.3)

Compressed gas containers, cylinders and tanks shall be secured to prevent falling caused by contact, vibration or seismic activity. Securing of compressed gas containers, cylinders and tanks shall be by one of the following methods:
1. Securing containers, cylinders and tanks to a fixed object with one or more restraints.
2. Securing containers, cylinders and tanks on a cart or other mobile device designed for the movement of compressed gas cylinders or tanks.
3. Securing of compressed gas containers, cylinders and tanks to or within a rack, framework, cabinet or similar assembly designed for such use.
4. Securing of compressed gas containers, cylinders and tanks to or within a rack, framework, cabinet or similar assembly designed for such use. (PFC - 3003.5.3)

Compressed gas containers, cylinders and tanks shall be protected from physical damage by means of protective caps, collars or similar devices. These devices must be in place, attached and in place at all times (PFC – 3003.6)

Compressed gas containers, cylinders and tanks designed for protective caps, collars or other protective devices shall have the caps or devices in place except when the containers, cylinders or tanks are in use or are being serviced or filled. (PFC – 3003.6.1)

Compressed gas containers, cylinders and tanks designed for valve protection caps or other protective devices shall have the caps or devices attached. When outlet caps or plugs are installed, they shall be in place. (PFC – 3003.6.2)

Unless otherwise specified in Section 3003.14 (Overhead Cover), compressed gas containers, cylinders and tanks are allowed to be stored or used without being placed under overhead cover. To prevent bottom corrosion, containers, cylinders and tanks shall be protected from direct contact with soil or unimproved surfaces. The surface of the area on which the containers are placed shall be graded to prevent accumulation of water. (PFC – 3003.13)

Compressed gas containers, cylinders and tanks are allowed to be stored or used in the sun except in locations where extreme temperatures prevail. When extreme temperatures prevail, overhead covers shall be provided. (PFC – 3003.14)
Guard posts or other approved means shall be provided to protect storage tanks and connected piping, valves and fittings; dispensing areas; and use areas subject to vehicular damage in accordance with Section 312. (PFC – 2703.9.3)

When processes or conditions exist where a flammable mixture could be ignited by static electricity, means shall be provided to prevent the accumulation of a static charge. (PFC – 2703.9.5)

Pressure Relief Devices

- Containers used for liquid carbon dioxide shall be equipped with pressure relief devices piped from the uppermost part of the containers and communicating with the vapor space. (NFPA 55 – 13.1.1)
- Bulk gas systems shall be provided with a source valve. (NFPA 55 – 6.18)
- The source valve shall be marked. (NFPA 55 – 6.18.1)
- The source valve shall be designated on the design drawings for the installation. (NFPA 55 – 6.18.2)
- Pressure relief devices to protect containers shall be designed and provided in accordance with CGA S-1.1, Pressure Relief Device Standards – Part 1 – Cylinders for Compressed Gases, for cylinders; CGA S-1.2, Pressure Relief Device Standards – Part 2 – Cargo and Portable Tanks for Compressed Gases, for portable tanks; and CGA S-1.3, Pressure Relief Device Standards – Part 3 – Stationary Storage Containers for Compressed Gases, for stationary tanks or in accordance with applicable equivalent requirements in the country of use. (NFPA 55 – 7.1.5.5.2)
- Pressure relief devices shall be sized in accordance with the specifications to which the container was fabricated. (NFPA 55 – 7.1.5.5.3)
- The pressure relief device shall have the capacity to prevent the maximum design pressure of the container or system from being exceeded. (NFPA 55 – 7.1.5.5.4)
- Pressure relief devices shall be arranged to discharge unobstructed to the open air in such a manner as to prevent any impingement of escaping gas upon the container, adjacent structures, or personnel. This requirement shall not apply to DOT specification containers having an internal volume of 2.0 ft³ (0.057 m³) or less. (NFPA 55 – 7.1.5.5.5)
- Pressure relief devices or vent piping shall be designed or located so that moisture cannot collect and freeze in a manner that would interfere with operation of the device. (NFPA 55 – 7.1.5.5.6)
- Pressure relief devices shall be provided to protect containers, cylinders and tanks containing compressed gases from rupture in the event of overpressure. Pressure relief devices or vent piping shall be sized or located so that moisture cannot collect and freeze in a manner that would interfere with the operation of the device. (PFC - 3003.3 - 3003.3.5)
- Pressure relief devices shall be provided to protect containers, cylinders and tanks containing compressed gases from rupture in the event of overpressure. (PFC- 3003.3.1)
- Pressure relief devices to protect containers shall be designed and provided in accordance with CGA S-1.1, CGA S-1.2, CGA S-1.3 or the ASME Boiler and Pressure Vessel Code, Section VIII, as applicable. (PFC - 3003.3.2)
- Pressure relief devices shall be sized in accordance with the specifications to which the container was fabricated and to material specific requirements as applicable. (PFC - 3003.3.3)
- Pressure relief devices shall be arranged to discharge upward and unobstructed to the open air in such a manner as to prevent any impingement of escaping gas upon the container, adjacent structures or personnel. (PFC - 3003.3.4)
- Pressure relief devices or vent piping shall be designed or located so that moisture cannot collect and freeze in a manner that would interfere with the operation of the device. (PFC-3003.3.5)
- Valves utilized on compressed gas systems shall be suitable for the use intended and shall be accessible. Valve handles or operators for required shutoff valves shall not be removed or otherwise altered to prevent access. (PFC= 3005.4)
- Pressure relief devices shall be provided to protect pressure vessels and systems containing compressed gases from rupturing in accordance with this section. Pressure relief devices shall be designed in accordance with nationally recognized standards. See Chapter 45 (Referenced Standards), CGA Standard S-1.3 or the ASME Boiler and Pressure Vessel Code. (PFC – 2703.2.10.3)
Stationary pressure vessels shall be provided with one or more pressure relief devices. (PFC – 2703.2.10.4.1)

Heat exchangers, compressors, gas vaporizers or reactors that are connected to a pressure vessel shall be provided with a pressure relief device. (PFC – 2703.2.10.4.2)

Pressure relief devices shall be sized in accordance with American Petroleum Institute RP 520 Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries, Part I – Sizing and Selection 7th Edition or Compressed Gas Association S-1.3 Pressure Relief Device Standards – Part 3 – Stationary Storage Containers for Compressed Gases 7th Edition. The relief device shall have sufficient capacity to prevent the maximum design pressure of the container or system from being exceeded at the container’s design temperature. Calculations of the required flow rate and opening pressure for a pressure relief device shall assume that the pressure vessel is exposed to the thermal radiation of a fire or the energy of a chemical reaction. (PFC – 2703.2.10.4.3)

All new pressure relief devices shall be marked with the letters “NB” to indicate that the device meets the requirements of the National Board of Boiler & Pressure Vessel Inspectors. Relief devices that are repaired shall be marked with the letters “VR” or equivalent language to indicate the valve repair meets the requirements of the National Board of Boiler & Pressure Vessel Inspectors. (PFC – 2703.2.10.4.5)

**Vent Pipe Systems**

- Pressure relief devices shall be piped to the outdoors where the discharge will not impinge on the structure, personnel, or means of egress and will not create a hazardous concentration of carbon dioxide. (NFPA 55 – 13.1.1.2)
- Pressure relief devices from portable DOT 4L containers that are not a component of a stationary system shall not be required to meet the requirements of NFPA 55 - 13.1.1.2. (NFPA 55 – 13.1.1.2.1)
- Vent piping systems serving pressure relief devices shall be protected from water intrusion to prevent moisture or solid carbon dioxide from collecting and freezing and interfering with the operation of the pressure relief device. (NFPA 55 – 13.1.1.2.2)
- Vent piping systems serving pressure relief devices shall be designed to prevent backflow restrictions exceeding 10 percent backpressure on the pressure relief device under full flow conditions. (NFPA 55 – 13.1.1.2.3)
- 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 the gas from the escaping plume to the supply system, personnel, adjacent structures and ignition sources. (NFPA 55 – 6.14)

**Pressure and Level Indicators**

- Containers, cylinders, and tanks shall be provided with a pressure gauge and a level gauge or device for indicating the quantity of liquid carbon dioxide. (NFPA 55 – 13.1.2.1)
- These devices shall be designed for the temperatures and pressures associated with liquid carbon dioxide service. (NFPA 55 – 13.1.2.2)
- Where containers, cylinders, and tanks are in locations remote from the filling connection, a means to determine when the containers have been filled to their design capacity shall be provided and shall be verifiable from the filling connection. (NFPA 55 – 13.1.2.3)
- Excess flow valves shall be provided on all containers, cylinders and tanks of compressed gases with a health hazard rating of 3 or 4, a flammability rating of 4 or a reactivity rating of 3 or 4 per NFPA 704. The location of the excess flow control shall be as follows: A) Where piping originates from a fixed source located in a room or area, the excess flow control shall be located within the room or area.
  B) Where piping originates from a portable source, the excess flow control shall be as close to the portable source as possible. (PFC – 3005.11)
Piping Systems

- Carbon dioxide piping shall be located and supported to protect against damage from strain on piping and fittings; the effects of expansion, contraction, and vibration; mechanical damage; and heat sources. (NFPA 55 – 13.1.3.1)
- Piping, tubing, and hoses and fittings shall be designed to a bursting pressure of at least four times the system design pressure. (NFPA 55 – 13.1.3.2)
- Materials of construction shall be employed for potential exposure to a temperature of −109.3°F (−78.5°C). (NFPA 55 – 13.1.4)
- Piping contents and direction of flow shall be identified in accordance with Chapter 27 (Hazardous Materials-General Provisions). (PFC - 3003.4.3)
- Piping, including tubing, valves, fittings and pressure regulators, shall comply with this section and Chapter 27 (Hazardous Materials-General Provisions). Piping, tubing, pressure regulators, valves and other apparatus shall be kept gas tight to prevent leakage. (PFC – 3005.3)
- Piping, tubing, valves, fittings and related components used for hazardous materials shall be in accordance with the following:
  1. Piping, tubing, valves, fittings and related components shall be designed and fabricated from materials that are compatible with the material to be contained and shall be of adequate strength and durability to withstand the pressure, structural and seismic stress and exposure to which they are subject. Piping systems shall be designed, constructed, and tested in accordance with ASME/ANSI B31.3 Process Piping 2004 edition.
  2. Piping and tubing shall be identified to indicate the material conveyed and the direction of flow. Pipe labels (6096 mm) shall be provided at a maximum spacing of 20 feet at each change of direction and on both sides of walls or floor/ceilings penetrations.
  3. Readily accessible manual valves or automatic remotely activated fail-safe emergency shutoff valves shall be installed on supply piping and tubing at the following locations:
     3.1. The point of use.
     3.2. The tank, cylinder or bulk source.
  4. Emergency shut of valves shall be identified and the location shall be clearly visible and accessible and indicated by means of a sign. When hazardous materials are stored outside of buildings in stationary above-ground tanks or pressure vessels and are piped into a building, an emergency shutoff valve shall be installed at an approved location outside of the building.
  5. Backflow prevention or check valves shall be provided when the backflow of hazardous materials could create a hazardous condition or cause the unauthorized discharge of hazardous materials.
  6. Where gases or liquids having a hazard ranking of:
     - Health hazard Class 3 or 4
     - Flammability Class 4
     - Reactivity Class 3 or 4

     in accordance with NFPA 704 are carried in pressurized piping above 15 pounds per square inch gauge (psig) (103 kPa), an approved means of leak detection and emergency shutoff or excess flow control shall be provided. Where the piping originates from within a hazardous material storage room or area, the excess flow control shall be located within the storage room or area. Where the piping originates from a bulk source, the excess flow control shall be located as close to the bulk source as practical.
  7. Pressure tests of piping constructed of nonmetallic material used to convey hazardous materials shall be limited to hydrostatic tests. Pneumatic pressure testing of nonmetallic piping shall not be permitted. (PFC – 2703.2.2.1)
- Supply piping and tubing for gases and liquids having a health-hazard ranking of 3 or 4 in accordance with NFPA704 shall be in accordance with ASME B31.3 and the following:
  1. Piping and tubing utilized for the transmission of highly toxic, toxic or highly volatile corrosive liquids and gases shall have welded, threaded or flanged connections throughout except for connections located within a ventilated enclosure if the material is a gas, or an approved method of drainage or containment is provided for connections if the material is a liquid.
2. Piping and tubing shall not be located within corridors, within any portion of a means of egress required to be enclosed in fire-resistance-rated construction or in concealed spaces in areas not classified as Group H occupancies. (PFC - 2703.2.2.2)

VENTILATION

*Because CO2 is heavier than air an approved means of ventilation is required.

*Planning and Development Department Ventilation Guideline - Attachment

- 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 material as stored. (NFPA 55 – 6.15)
- Where mechanical ventilation is provided, the system shall be operational during the time the building or space is occupied. (NFPA 55 – 6.15.1)
- Mechanical ventilation shall be at a rate of not less than 1 ft³/min/ft² (0.3048 m³/min/m²) of floor area over the area of storage or use. (NFPA 55 – 6.15.3)
- Systems shall operate continuously unless an alternative design is approved by the AHJ. (NFPA 55 – 6.15.4)
- Where powered ventilation is provided, a manual shutoff switch shall be provided outside the room in a position adjacent to the principal access door to the room or in an approved location. (NFPA 55 – 6.15.5)
- The switch shall be the break glass or equivalent type and shall be labeled as follows: WARNING: VENTILATION SYSTEM EMERGENCY SHUTOFF (NFPA 55 – 6.15.6)
- Venting of gases shall be directed to an approved location. Venting shall comply with the International Mechanical Code. (PFC – 3005.5)
- Indoor dispensing and use areas shall be provided with exhaust ventilation in accordance with Section 2704.3 (Ventilation). (PFC - 2705.1.9)
- Indoor storage areas and storage buildings shall be provided with mechanical exhaust ventilation or natural ventilation where natural ventilation can be shown to be acceptable for the materials as stored. (PFC 06 – 2704.3)
- Exhaust ventilation systems shall comply with all of the following:
  1. Installation shall be in accordance with the International Mechanical Code.
  2. Mechanical ventilation shall be at a rate of not less than 1 cubic foot per minute per square foot [0.00508 m³/(s • m²)] of floor area over the storage area.
  3. Systems shall operate continuously unless alternative designs are approved.
  4. A manual shutoff control shall be provided outside of the room in a position adjacent to the access door to the room or in an approved location. The switch shall be a break-glass or other approved type and shall be labeled: VENTILATION SYSTEM EMERGENCY SHUT OFF.
  5. Exhaust ventilation shall be designed to consider the density of the potential fumes or vapors released. For fumes or vapors that are heavier than air, exhaust shall be taken from a point within 12 inches (305 mm) of the floor. For fumes or vapors that are lighter than air, exhaust shall be taken from a point within 12 inches (305 mm) of the highest point of the room.
  6. The location of both the exhaust and inlet air openings shall be designed to provide air movement across all portions of the floor or room to prevent the accumulation of vapors.
  7. Exhaust air shall not be re-circulated to occupied areas if the materials stored are capable of emitting hazardous vapors and contaminants have not been removed.
    Air-contaminated with explosive or flammable vapors, fumes or dusts; flammable, highly toxic or toxic gases; or radioactive materials shall not be re-circulated. (PFC 06 – 2704.3.1)
- Where closed systems are designed to be opened as part of normal operations, ventilation shall be provided in accordance with Section 2705.2.1.1 (Ventilation). (PFC 06 – 2705.2.2.2)
- Where gases, liquids or solids having a hazard ranking of 3 or 4 in accordance with NFPA 704 are dispensed or used, mechanical exhaust ventilation shall be provided to capture gases, fumes, mists or vapors at the point of generation. (PFC – 2705.2.1.1)
**Inlets to the Exhaust System**

- The exhaust ventilation system design shall take into account the density of the potential gases released. (NFPA 55 – 6.15.7.1)
- For gases that are heavier than air, exhaust shall be taken from a point within 12 in. (304.8 mm) of the floor. (NFPA 55 – 6.15.7.2)
- For gases that are lighter than air, exhaust shall be taken from a point within 12 in. (304.8 mm) of the ceiling. (NFPA 55 – 6.15.7.3)
- The location of both the exhaust and inlet air openings shall be designed to provide air movement across all portions of the floor or room to prevent the accumulation of vapors. (NFPA 55 – 6.15.8)
- 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. (NFPA 55 – 6.15.9)
- Ventilation systems shall discharge a minimum of 50 ft (15 m) from intakes of air-handling systems, air-conditioning equipment, and air compressors. (NFPA 55 – 6.15.10)
- Storage and use of compressed gases shall be located not less than 50 ft (15 m) from air intakes. For material-specific requirements, see Sections 7.4 through 7.10. (NFPA 55 – 6.15.11)

**Indoor Systems - Small Insulated Liquid Carbon Dioxide Indoor Systems**

- Container foundations or floors in multistoried buildings shall be designed to support the weight of the system at its full capacity in accordance with the building code. (NFPA 55 – 13.2.1)
- Rooms or areas where container systems are filled and used indoors or in enclosed outdoor locations shall be provided with a gas detection and alarm system that is capable of detecting and notifying the building occupants of a gas release that creates carbon dioxide vapors in excess of its PEL. (NFPA 55 – 13.2.2)
- Activation of the gas detection system shall initiate an audible alarm within the room or area in which the system is installed. (NFPA 55 – 13.2.2.1)
- Activation of the gas detection system shall sound a local alarm to notify persons responsible for system operation of a hazard condition in the area in which the system is installed. (NFPA 55 – 13.2.2.3)
- A warning sign shall be posted at the entrance to the building, room, enclosure, or confined area where the container is located. (NFPA 55 – 13.2.3)
- The warning sign shall be at least 8 in. (200 mm) wide and 6 in. (150 mm) high and state the following:
  
  **CAUTION — CARBON DIOXIDE GAS**
  Ventilate the area before entering.
  A high carbon dioxide (CO2) gas concentration in this area can cause suffocation (NFPA 55 – 13.2.3.1)
- A stationary pressure vessel located inside of a building shall meet the following requirements:
  1. The pressure relief device shall be terminated outside of the building. The termination shall be in accordance with Section 1504.2.6.
  2. The diameter of the discharge piping shall be equal or greater in diameter that the diameter of the pressure relief device discharge opening.
  3. When multiple pressure relief devices are terminated into a single discharge relief manifold, the cross-sectional area of the manifold shall equal or exceed the sum of the pressure relief device discharge openings.
  4. A pressure relief device shall not support discharge piping.
  5. The discharge piping shall be protected from water resulting from rain or condensation. (PFC – 2703.2.10.5)

**Outdoor Systems - Small Insulated Liquid Carbon Dioxide Outdoor Systems**

- Aboveground outdoor locations shall not be required to be provided with a gas detection and alarm system in accordance with 13.2.2 (NFPA 55) where the system is unenclosed. (NFPA 55 – 13.3.3.1)
Gas Detection and Monitoring

- Gas detection equipment shall be listed for detection of the specific gas or vapor to be encountered. (NFPA 72 - 17.10.2)
- Any gas detection systems installed on a fire alarm system shall comply with all the applicable requirements of Chapters 1, 10, 14, 17, and 23 of NFPA 72. (NFPA 72 - 17.10.2.2).
- The selection and placement of the gas detectors shall be based on an engineering design. (NFPA 72 - 17.10.2.4).
- Manual alarm, detection and automatic fire-extinguishing systems required by other provisions of Section 2705 (Use, Dispensing and Handling) shall be supervised by an approved central, proprietary or remote station service or shall initiate an audible and visual signal at a constantly attended on-site location. (PFC - 2705.1.6)
- Where hazardous materials having a hazard ranking of 3 or 4 in accordance with NFPA 704 are transported through corridors or exit enclosures, there shall be an emergency telephone system, a local manual alarm station or an approved alarm-initiating device at not more than 150-foot (45,720 mm) intervals and at each exit and exit access doorway throughout the transport route. The signal shall be relayed to an approved central station, proprietary supervising station or remote supervising station or a constantly attended on-site location and shall also initiate a local audible alarm. (PFC – 2705.4.4)

Signage/Markings

- Signs and markings required and 2703.5.1 (Markings) shall not be obscured or removed, shall be in English as a primary language or in symbols allowed by this code, shall be durable, and the size, color and lettering shall be approved. (PFC- 2703.6)
- Smoking shall be prohibited and “No Smoking” signs provided as follows: 1. In rooms or areas where hazardous materials are stored or dispensed or used in open systems in amounts requiring a permit in accordance with Section 2701.5 (Permits and plans).(PFC- 2703.7.1)
- A warning sign shall be posted at the entrance to the building, room, enclosure, or confined area where the container is located. (NFPA 55 – 13.2.3)
The warning sign shall be at least 8 in. (200 mm) wide and 6 in. (150 mm) high and state the following:

CAUTION — CARBON DIOXIDE GAS
Ventilate the area before entering
A high carbon dioxide (CO2) gas concentration in this area can cause suffocation. (NFPA 55 – 13.2.3.1)

Hazard identification signs shall be placed at all entrances to locations where compressed gases are produced, stored, used, or handled in accordance with NFPA704, Standard System for the Identification of the Hazards of Materials for Emergency Response. (NFPA 55 – 6.11.1)

Ratings shall be assigned in accordance with NFPA 704. (NFPA 55 – 6.11.1.1)

Signs shall not be obscured or removed. (NFPA 55 – 6.11.2.1)

Signs prohibiting smoking or open flames within 25 ft (7.6 m) of area perimeters shall be provided in areas where toxic, highly toxic, corrosive, unstable reactive, flammable, oxidizing, or pyrophoric gases are produced, stored, or used. (NFPA 55 – 6.11.2.2)

Marking – Stationary compressed gas containers, cylinders, tanks and systems shall be marked with the name of the gas and in accordance with PFC sections 2703.5 (Hazard Identification Signs) and 2703.6 (Signs). These markings shall be visible from any direction of approach. Portable containers, cylinders and tanks shall be marked in accordance with CGA C-7. (PFC -3003.4.2)

Unless otherwise exempted by the fire code official, visible hazard identification signs as specified in NFPA 704 for the specific material contained shall be placed on stationary containers and above-ground tanks and at entrances to locations where hazardous materials are stored, dispensed, used or handled in quantities requiring a permit and at specific entrances and locations designated by the fire code official. An NFPA704 hazard diamond installed at an outdoor location shall meet the fire department sign specification. (PFC – 2703.5)

Individual containers, cartons or packages shall be conspicuously marked or labeled in an approved manner. Rooms or cabinets containing compressed gases shall be conspicuously labeled: COMPRESSED GAS. (PFC– 2703.5.1)

Signs and markings required by Sections 2703.5 (Hazard Identification Signs) and 2703.5.1 (Markings) shall not be obscured or removed, shall be in English as a primary language or in symbols allowed by this code, shall be durable, and the size, color and lettering shall be approved. (PFC 06 – 2703.6)

Smoking shall be prohibited and “No Smoking” signs provided as follows:
1. In rooms or areas where hazardous materials are stored or dispensed or used in open systems in amounts requiring a permit in accordance with Section 2701.5 (Permits and plans).
2. With in 25 feet (7620 mm) of outdoor storage, dispensing or open use areas.
3. Facilities or areas within facilities that have been designated as totally “No Smoking” shall have “No Smoking” signs placed at all entrances to the facility or area. Designated areas within such facilities where smoking is permitted either permanently or temporarily, shall be identified with signs designating that smoking is permitted in these areas only.
4. In rooms or areas where flammable or combustible hazardous materials are stored, dispensed or used.

Signs required by this section shall be in English as a primary language or in symbols allowed by this code and shall comply with Section 310 (Smoking). (PFC – 2703.7.1)

Maintenance

Equipment, machinery and required detection and alarm systems associated with the use, storage or handling of hazardous materials shall be listed or approved. (PFC 2703.2.3)

In addition to the requirements of Section 2703.2.3 (Design and Construction of containers, cylinders and tanks) equipment, machinery and required detection and alarm systems associated with hazardous materials shall be maintained in an operable condition. Defective containers, cylinders and tanks shall be removed from service, repaired or disposed of in an approved manner. Defective equipment or machinery shall be removed from service and repaired or replaced. Required detection and alarm systems shall be replaced or repaired where defective. (PFC 06 – 2703.2.6)
- Defective containers, cylinders, and tanks shall be returned to the supplier. (NFPA 55 – 7.1.5.2.1)
- Suppliers shall repair the containers, cylinders, and tanks, remove them from service, or dispose of them in an approved manner. (NFPA 55 – 7.1.5.2.2)
- Service, repair, modification or removal of valves, pressure-relief devices or other compressed gas container, cylinder or tank appurtenances shall be performed by trained personnel. (PFC – 3003.9)
- When a stationary pressure vessel is repaired or is modified, an ASME R-1 report shall be made available to the fire department. Upon completion of the repairs or modifications to a pressure vessel, a nameplate indicating the nature of the work shall be affixed to the pressure vessel. The repair nameplate shall be affixed near the original nameplate. (PFC – 2703.2.10.2)

**General Safety Precautions**

- Personnel training and written procedures. Persons responsible for the operation 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. (PFC - 2703.9.1)
- Operating instructions shall account for potential exposure of personnel to extremely low temperatures in accordance with NFPA 55 13.2.3 (NFPA 55)
- An emergency plan shall be prepared and updated wherever compressed gases or cryogenic fluids are produced, handled, stored, or used in amounts exceeding the maximum allowable quantity (MAQ) per control area or where required by the authority having jurisdiction (AHJ). (NFPA 55 – 4.2.1.1)
- The plan shall be available for inspection by the AHJ upon reasonable notice and shall include the following information:
  1. The type of emergency equipment available and its location
  2. A brief description of any testing or maintenance programs for the available emergency equipment
  3. An indication that hazard identification labeling is provided for each storage area
  4. The location of posted emergency procedures
  5. A material safety data sheet (MSDS) or equivalent for each compressed gas or cryogenic fluid stored or used on the site
  6. A list of personnel who are designated and trained to be liaison personnel for the fire department and who are responsible for the following:
     a. Aiding the emergency responders in pre-emergency planning
     b. Identifying the location of the compressed gases and cryogenic fluids stored or used
     c. Accessing MSDSs
     d. Knowing the site emergency procedures
  7. A list of the types and quantities of compressed gases and cryogenic fluids found within the facility. (NFPA 55 – 4.2.1.2)
- Compressed gas containers, cylinders, tanks and systems shall not be used for any purpose other than to serve as a vessel for containing the product which it is designed to contain. (PFC – 3003.10)
- Compressed gas containers, cylinders and tanks which have been exposed to fire shall be removed from service. Containers, cylinders and tanks so removed shall be handled by approved qualified persons. (PFC – 3003.11)
- Leaking, damaged or corroded compressed gas containers, cylinders and tanks shall be removed from service. Leaking, damaged or corroded compressed gas systems shall be replaced or repaired in accordance with the following:
  1. Compressed gas containers, cylinders and tanks which have been removed from service shall be handled in an approved manner.
  2. Compressed gas systems which are determined to be leaking, damaged or corroded shall be repaired to a serviceable condition or removed from service. (PFC – 3003.12)
- Compressed gas containers, cylinders and tanks, except those designed for use in a horizontal position, and all compressed gas containers, cylinders and tanks containing non liquefied gases, shall be used in an upright position with the valve end up. An upright position shall include conditions...
where the container, cylinder or tank axis is inclined as much as 45 degrees (0.80 rad) from the vertical. Use of nonflammable liquefied gases in the inverted position when the liquid phase is used shall not be prohibited provided that the container, cylinder or tank is properly secured and the dispensing apparatus is designed for liquefied gas use. (PFC – 3005.6)

- Transfer of gases between containers, cylinders and tanks shall be performed by qualified personnel using equipment and operating procedures in accordance with CGA P-1. (PFC – 3005.7)

**Separation from hazardous conditions**

- Compressed gas containers, cylinders and tanks and systems in storage or use shall be separated from materials and conditions which pose exposure hazards to or from each other. (PFC – 3003.7)
- Compressed gas containers, cylinders and tanks shall be separated from each other based on the hazard class of their contents. Compressed gas containers, cylinders and tanks shall be separated from incompatible materials in accordance with Section 2703.9.8 (Separation of incompatible materials). (PFC – 3003.7.1)
- Combustible waste, vegetation and similar materials shall be kept a minimum of 10 feet (3048 mm) from compressed gas containers, cylinders, tanks and systems. A noncombustible partition, without openings or penetrations and extending not less than 18 inches (457 mm) above and to the sides of the storage area is allowed in lieu of such distance. The wall shall either be an independent structure, or the exterior wall of the building adjacent to the storage area. (PFC – 3003.7.2)
- Compressed gas containers, cylinders and tanks shall not be placed near elevators, unprotected platform ledges or other areas where falling would result in compressed gas containers, cylinders or tanks being allowed to drop distances exceeding one-half the height of the container, cylinder or tank. (PFC – 3003.7.3)
- Compressed gas containers, cylinders and tanks, whether full or partially full, shall not be exposed to artificially create high temperatures exceeding 125°F (52°C) or sub ambient (low) temperatures unless designed for use under the exposed conditions. (PFC – 3003.7.4)
- Compressed gas containers, cylinders, tanks and systems shall not be placed in areas where they are capable of being damaged by falling objects. (PFC – 3003.7.5)
- Compressed gas containers, cylinders and tanks, whether full or partially full, shall not be heated by devices which could raise the surface temperature of the container, cylinder or tank to above 125°F (52°C). Heating devices shall comply with the International Mechanical Code and the National Electrical Code. Approved heating methods involving temperatures of less than 125°F (52°C) are allowed to be used by trained personnel. Devices designed to maintain individual compressed gas containers, cylinders or tanks at constant temperature shall be approved and shall be designed to be fail-safe. (PFC – 3003.7.6)
- Open flames and high-temperature devices shall not be used in a manner which creates a hazardous condition. (PFC – 3003.7.7)
- Compressed gas containers, cylinders, tanks and systems shall not be exposed to corrosive chemicals or fumes which could damage containers, cylinders, tanks, valves or valve-protective caps. (PFC – 3003.7.8)
- When exhausted enclosures are provided as a means to segregate compressed gas containers, cylinders and tanks from exposure hazards, such enclosures shall comply with the requirements of Section 2703.8.5 (Exhausted enclosures). (PFC – 3003.7.9)
- Incompatible materials in storage and storage of materials that are incompatible with materials in use shall be separated when the stored materials are in containers having a capacity of more than 5 pounds (2 kg) or 0.5 gallon (2 L). Separation shall be accomplished by:
  1. Segregating incompatible materials in storage by a distance of not less than 20 feet (6096 mm).
  2. Isolating incompatible materials in storage by a noncombustible partition extending not less than 18 inches (457 mm) above and to the sides of the stored material.
  3. Storing liquid and solid materials in hazardous material storage cabinets.
  4. Storing compressed gases in gas cabinets or exhausted enclosures in accordance with Sections 2703.8.5 (Exhausted enclosures) and 2703.8.6 (Gas cabinets). Materials that are incompatible shall not be stored within the same cabinet or exhausted enclosure.
5. A secondary containment or drainage system for each class of incompatible hazardous materials stored in stationary or portable tanks. (PFC - 2703.9.8)

**HOW CAN I OBTAIN MORE INFORMATION:**

If this fire code summary does not answer your questions, please feel free to contact the Phoenix Fire Department Fire Prevention Division at 602-256-3434 or 602-262-6771 or E-mail your inquiries to: phoenix.fire.prevention@phoenix.gov.

Requests for information about Structural, Plumbing, Mechanical and Electrical Code requirements should be directed to the Planning and Development Department 602-262-7811 or the City of Phoenix Business Resource Line 602-534-2489.

Refer to the Compressed Gas Association Safety Alert (SA-22, 2011) – Carbonated Beverage Systems www.cganet.com

**Telephony or e-mail messages regarding particular code requirements to the Phoenix Fire Department are not official interpretations. An official interpretation requires a plan review or written correspondence that requests an official interpretation, the referenced code section(s) **AND** includes sufficient information to interpret if the applicable code section(s) applies.**
Purpose

The purpose of this guideline is to establish methods of compliance for ventilating building spaces containing liquid carbon dioxide (CO2) vessels and systems. Carbon dioxide poses a serious asphyxiation hazard compared to other gases. The Phoenix Fire Department has determined that all liquid CO2 systems shall be provided with a ventilation system in compliance with NFPA 55 and the International Mechanical Code (IMC). The following requirements shall be included in the design of the ventilation system.

Section 501.2.1 Location of exhaust outlets. The termination point of exhaust outlets and ducts discharging to the outdoors shall be located 10 feet from property lines, 3 feet from exterior walls and roofs, 10 feet from operable openings into the building, and 10 feet above adjoining grade.

Section 502.8.1.1 System requirements. Exhaust ventilation systems shall comply with all of the following:

1. The installation shall be in accordance with this code.
2. Mechanical ventilation shall be provided at a rate of not less than 1 cfm per square foot of floor area over the storage area.
3. The systems shall operate continuously unless alternate designs are approved.
4. A manual shutoff control shall be provided outside of the room in a position adjacent to the access door to the room or in another approved location. The switch shall be a break-glass or other approved type and shall be labeled: VENTILATION SYSTEM EMERGENCY SHUTOFF.
5. The exhaust ventilation shall be designed to consider the density of the potential fumes or vapors. For fumes or vapors that are heavier than air, such as CO2, exhaust shall be taken from a point within 12 inches of the floor.
6. The location of both the exhaust and inlet air openings shall be designed to provide air movement across all portions of the floor or room to prevent the accumulation of vapors.
7. The exhaust air shall not be recirculated to occupied areas.

Section 502.8.4 Indoor dispensing and use – point sources. Mechanical exhaust ventilation shall be provided to capture gases, fumes, mists or vapors at the point of generation.

Section 510.5.5 Makeup air. Makeup air shall be provided at a rate approximately equal to the rate that air is exhausted. Makeup-air intakes shall be located so as to avoid recirculation of contaminated air.