Carbonated Beverage CO2 Storage Systems
**MOLECULAR FORMULA:** CO2

**MOLECULAR WEIGHT (MW) =** 44

**CAS #:** 124-38-9

**APPEARANCE:** Colorless

**ODOR:** Odorless, but with a slightly pungent odor and biting or acidic taste may be noticed at high concentrations
- **SPECIFIC GRAVITY (gas) (Air=1):** 1.522 @ 70°F and 1 atm.

- **SPECIFIC VOLUME:** 8.741 cu. ft/lb @ 70°F and 1 atm.

- **BOILING POINT:** -109.3°F (sublimation temperature)
HAZARDS:

- GENERAL: Asphyxiant; contact with liquid or solid may cause frostbite.
- ROUTES OF EXPOSURE: Inhalation (gas); skin and eyes (liquid or solid phase).
- TARGET ORGANS: Respiratory system; central nervous system; heart.
- EXPOSURE DATA: NIOSH IDLH: 40,000 ppm TLV: 5,000 ppm
<table>
<thead>
<tr>
<th>TLV-TWA</th>
<th>Stel (15mon)</th>
<th>IDLH</th>
<th>Minimum level allowed by OSHA considered IDLH</th>
<th>Increased respiration impaired judgment coordination and perception</th>
<th>8 min - 100% fatal</th>
<th>6 min 50% fatal</th>
<th>4 min Recovery with Treatment</th>
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<tbody>
<tr>
<td>0 ppm</td>
<td>5,000 ppm</td>
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What Carbon Dioxide Can Do To You

Main symptoms of Carbon dioxide toxicity

- Visual
  - Dimmed sight

- Central
  - Drowsiness
  - Mild narcosis
  - Dizziness
  - Confusion
  - Headache
  - Unconsciousness

- Auditory
  - Reduced hearing

- Respiratory
  - Shortness of breath

- Skin
  - Sweating

- Muscular
  - Tremor

- Heart
  - Increased heart rate and blood pressure
Code sections referenced in the PowerPoint are from the 2012 IFC unless notes
Chapter 2

- **COMPRESSED GAS SYSTEM.** 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.

- **CRYOGENIC FLUID.** A fluid having a boiling point lower than -130°F at 14.7 pounds per square inch atmosphere (psia) (an absolute pressure of 101.3 kPa).
So is CO2 a compressed gas or a cryogenic fluid?
Chapter 2

HAZARDOUS MATERIALS. Those chemicals or substances which are physical hazards or health hazards as defined and classified in this chapter, whether the materials are in usable or waste condition.
Chapter 2

**PHYSICAL HAZARD.** A chemical for which there is evidence that it is a combustible liquid, cryogenic fluid, explosive, flammable (solid, liquid or gas), organic peroxide (solid or liquid), oxidizer (solid or liquid), oxidizing gas, pyrophoric (solid, liquid or gas), unstable (reactive) material (solid, liquid or gas) or water-reactive material (solid or liquid).
Chapter 2

- **HEALTH HAZARD.** A classification of a chemical for which there is statistically significant evidence that acute or chronic health effects are capable of occurring in exposed persons. The term “health hazard” includes chemicals that are toxic, highly toxic and *corrosive*. 
So is CO2 a health or physical hazard?

So can we use Chapter 50?
Chapter 53

5301.1 Scope. Storage, use and handling of compressed gases in compressed gas containers, cylinders, tanks and systems shall comply with this chapter, including those gases regulated elsewhere in this code. Partially full compressed gas containers, cylinders or tanks containing residual gases shall be considered as full for the purposes of the controls required.
Characteristics of DOT Cylinders

- They normally come in sizes from 10 pound to 100 pounds
- The cylinders can be rated as high as 1800 psi
- Are normally filled at a bulk gas suppliers' place of business
- Filling and corresponding size that the industry gives these vessels is based on the weight of the liquid CO2 they hold. (A 10 pound cylinder is filled with 10 pounds of liquid CO2)
Characteristics of DOT Cylinders

- They are transported to businesses for use in beverage systems.

- Are typically connected to the beverage system by employees of the business selling the beverages.

- Change out frequency varies based on size of tank and usage.

- Typically spare cylinders are kept on hand to replace empty cylinders.
Characteristics of DOT Cylinders

They are equipped with a burst disc that protects the cylinder from over pressurization.

Burst disc or rupture disc have a thin metallic disc designed to fail at a given pressure.

Installation of a burst disc of the proper set pressure is the responsibility of certified DOT cylinder testing shops and is based on the cylinders maximum designed working pressure.
DOT CO2 Cylinders
Burst Disc
All ASME (American Society for Mechanical Engineers) certified cylinders are required to have a Data Plate permanently attached to the cylinder or a frame that is permanently attached to the cylinder.
Characteristics of ASME Vessels

The information provided on the Data plate includes

- ASME Code Symbol Stamp
- National Board Registration Number
- Cylinder Manufacturer
- The Maximum Allowable Working Pressure of the tank or MAWP
Characteristics of ASME Vessels

Inspection should include verifying the cylinder is fitted with the proper safety device.

It should be noted that some older tanks have a maximum allowable working pressure of 287 psi. It is not uncommon for these cylinders to be improperly fitted with a 300 psi safety device.
Characteristics of ASME Vessels

The code required primary safety device is a spring loaded safety device. This type of device is designed to reseat within a percentage of the set pressure stamped on the device.

The secondary device is a burst disc “that is a disc that burst or breaks open at a set pressure”. These disc do not reseat and are much like a pop top on a beverage container.
NAT'L. BD. NO.
111362
CERTIFIED BY
MVE, INC.

M.A.W.P. 300 PSI AT 100°F
M.D.M.T. -320°F AT 300 PSI

1999 S/NCJAE99K130
DUPLICATE

CRN-K3359.21345678
5303.3.4 Arrangement. 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.
5303.4.3 Piping systems. Piping systems shall be marked in accordance with ASME A13.1. Markings used for piping systems shall consist of the content’s name and include a direction-of-flow arrow. Markings shall be provided at each valve; at wall, floor or ceiling penetrations; at each change of direction; and at a minimum of every 20 feet (6096 mm) or fraction thereof throughout the piping run.
SECTION 5307 COMPRESSED GASES NOT OTHERWISE REGULATED

5307.2 Ventilation. Indoor storage and use areas and storage buildings shall be provided with mechanical exhaust ventilation or natural ventilation in accordance with the requirements of Section 5004.3 or 5005.1.9. When mechanical ventilation is provided, the systems shall be operational during such time as the building or space is occupied.
1.1 Scope.

1.1.1 Applicability. This code shall apply to the installation, storage, use, and handling of compressed gases and cryogenic fluids in portable and stationary containers, cylinders, equipment, and tanks in all occupancies.
6.7* Employee Alarm System. Where required by government regulations, an employee alarm system shall be provided to allow warning for necessary emergency action as called for in the emergency action plan required by 4.2.1.1, or for reaction time for safe egress of employees from the workplace or the immediate work area, or both.
6.11 Hazard Identification Signs.

6.11.1 Location. 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*.

6.11.1.1 Ratings shall be assigned in accordance with NFPA 704.

6.11.1.2 The authority having jurisdiction shall be permitted to waive 6.11.1 where consistent with safety.
6.15 Ventilation. 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.

- 6.15.1 Mechanical Ventilation. Where mechanical ventilation is provided, the system shall be operational during the time the building or space is occupied.

- 6.15.3 Mechanical Ventilation Rate. Mechanical ventilation shall be at a rate of not less than 1 ft³/min/ft² of floor area over the area of storage or use.

- 6.15.4 Continuous Operation. Systems shall operate continuously unless an alternative design is approved by the AHJ.
6.15.5 Shutoff Controls. 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.

6.15.6 Manual Shutoff Switch. The switch shall be the breakglass or equivalent type and shall be labeled as follows: WARNING: VENTILATION SYSTEM EMERGENCY SHUTOFF

Do you need this for CO2, remember the hazards
6.15.7 Inlets to the Exhaust System.

6.15.7.1 The exhaust ventilation system design shall take into account the density of the potential gases released.

6.15.7.2 For gases that are heavier than air, exhaust shall be taken from a point within 12 in. of the floor.

6.15.7.3 For gases that are lighter than air, exhaust shall be taken from a point within 12 in. of the ceiling.
NFPA 55, 2010 Edition

6.15.8 Floor Level Exhaust. 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.

6.15.9 Recirculation of Exhaust. Exhaust ventilation shall not be recirculated within the room or building if the cylinders, containers, or tanks stored are capable of releasing hazardous gases.
6.15.10 Ventilation Discharge. Ventilation systems shall discharge a minimum of 50 ft from intakes of air-handling systems, air-conditioning equipment, and air compressors.

6.15.11 Air Intakes. Storage and use of compressed gases shall be located not less than 50 ft from air intakes. For material-specific requirements, see Sections 7.4 through 7.10.

May not be able to get this due to the size of building / roof
7.1.2 Small Insulated Liquid Carbon Dioxide Systems. Small insulated liquid carbon dioxide systems shall be in accordance with Chapter 13.
13.1 General. The storage, use, and handling of liquid carbon dioxide in insulated systems shall be in accordance with the provisions of Chapter 13 and Chapters 1 through 7 as applicable.
13.1.1* 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.
13.1.1.2 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.

13.1.1.2.3 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.
13.1.3 Piping Systems.

13.1.3.1 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.

13.1.3.2 Piping, tubing, and hoses and fittings shall be designed to a bursting pressure of at least four times the system design pressure.

13.1.4* Materials of Construction. Materials of construction shall be employed for potential exposure to a temperature of −109.3°F.
Fill Systems

The most common system employs a permanently installed vessel, and outdoor-mounted CO2 fill box.

The fill line and vent line join the vessel to the outdoor fill box.
Fill and vent circuit wall penetrations must be sealed to prevent CO2 entry back in the building.

Note vent line not connected.
13.2.2* 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.

13.2.2.1* Activation of the gas detection system shall initiate an audible alarm within the room or area in which the system is installed.
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November 2013   Joe McElvaney
13.2.2.3 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.
No reference to NFPA 72, ADA and only audible alarm in room where vessels are storage/used

Phx has a policy that requires two notification devices rated at 100 cd / 75dba.

One in the room where the ASME vessel is stored and the other in a common space
13.2.3 A warning sign shall be posted at the entrance to the building, room, enclosure, or confined area where the container is located.

13.2.3.1 The warning sign shall be at least 8 in. wide and 6 in. 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.
CAUTION
CARBON DIOXIDE GAS

Ventilate area before entering.

Carbon dioxide (CO\textsuperscript{2}) gas in this area can cause suffocation.
EMERGENCY EXHAUST FAN START SWITCH
13.3 Small Insulated Liquid Carbon Dioxide Outdoor Systems.

13.3.1 Container systems located in enclosed spaces shall be in accordance with Section 13.2 for indoor systems.

13.3.1.1* Aboveground outdoor locations shall not be required to be provided with a gas detection and alarm system in accordance with 13.2.2 where the system is unenclosed.
To be considered unenclosed, enclosures constructed to limit access or otherwise provide a visual or architectural barrier for the installation shall be constructed in accordance with the requirements in 6.5.2 for weather protection or with the following:

1. The enclosure shall be constructed without a roof or overhead cover.

2. Supports and walls shall not obstruct more than three sides nor more than 75 percent of the perimeter of the storage or use area with 25 percent of the perimeter be in open to the atmosphere.
What about a service yard or a trash enclosure does this meet the requirement for outside installation?
Drink-thu Soda Machine
13.3.1.1.2 Enclosures that do not meet the requirements of 13.3.1.1 shall be permitted when constructed in accordance with the following:

1. The enclosure shall be constructed without a roof or overhead cover.

2. Continuous mechanical exhaust ventilation shall be provided.
13.3.1.1.2.1 Where mechanical exhaust ventilation is provided, it shall be in accordance with the following:

(1) The exhaust system shall be installed in accordance with the requirements of the mechanical code.

(2) The exhaust system shall be designed to consider the density of the potential vapors released with exhaust taken from a point within 12 in. of the floor.
(3) The location of both the exhaust and the inlet air openings shall be designed to provide air movement across all portions of the enclosure to prevent the accumulation of vapors.

(4) The rate of exhaust ventilation shall be not less than 1 ft³/min per square foot of floor area within the enclosure
Questions?

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