

AMENDMENTS TO THE BUILDING AND FIRE CODE FOR THE CITY AND COUNTY OF DENVER



The 2016 Denver Building and Fire Code includes the following codes except as amendment herein.

2015 IBC (Building)

2015 IFC (Fire)

2015 IEBC (Existing Building)

2015 IRC (Residential)

2015 IMC (Mechanical)

2015 IPC (Plumbing)

2015 IFGC (Fuel & Gas)

2015 IECC (Energy)

2014 National Electrical Code (or NEC version currently adopted by the State of Colorado)

CHAPTER 53 COMPRESSED GASES

Section 5307 Carbon Dioxide (CO₂) Systems Used in Beverage Dispensing Applications is replaced as follows:

SECTION 5307

CARBON DIOXIDE (CO₂) SYSTEMS USED IN BEVERAGE DISPENSING APPLICATIONS

5307.1 General. Carbon dioxide (CO₂) systems with more than 100 pounds (45.4 kg) of carbon dioxide or any system using any amount of carbon dioxide (CO₂) below grade used in beverage dispensing applications shall comply with Sections 5307.2 through 5307.8.

5307.2 Permits. Permits shall be required as set forth in Section 105 and in accordance with Denver Fire Department policy.

5307.3 Equipment. The storage, use, and handling of carbon dioxide shall be in accordance with IFC Chapter 53, as amended, and the applicable requirements of NFPA 55, Chapter 13. All equipment utilized in compressed gas systems shall be compatible with the intended gas and use.

5307.3.1 Containers, cylinders and tanks. Gas storage containers, cylinders and tanks shall be designed, fabricated, tested, labeled and installed in accordance with manufactures' specifications and shall be maintained in accordance with the regulations of DOTn 49 CFR, Parts 100-185 or the *ASME Boiler and Pressure Vessel Code*, Section VIII.

5307.3.1.1 Location. Location of gas storage containers, cylinders and tanks, inside or outside the building, shall be at an approved location.

5307.3.1.2 Security. Gas storage containers, cylinders and tanks shall be secured in an approved manner to prevent overturning. Containers, cylinders and tanks located outside shall be secured and safeguarded against tampering and protected from physical damage if exposed to vehicle traffic.

5307.3.1.3 Design and construction. Bulk tank installations over 2,000 pounds will require an engineered foundation and construction permit in accordance with the *Denver Building Code*.

5307.3.2 Piping systems. Piping, tubing, fittings, valves and pressure regulating devices shall be designed and installed in accordance with approved standards and manufacturers' recommendations.

5307.3.2.1 Piping, tubing and hoses. Piping, tubing and hose materials shall be compatible with carbon dioxide and rated for the temperatures and pressures encountered in the system. All hoses and tubing used in carbon dioxide service shall be designed for a bursting pressure of at least four times their design pressure. PVC/ABS and other types of rigid plastic piping are not approved materials. Acceptable piping for carbon dioxide shall be the following:

1. Stainless steel A269 grade, which is either seamless or welded drawn over mandrel
2. Copper K grade, hard drawn seamless
3. Copper ACR grade (1/2 inch outside diameter or less) annealed seamless

4. Plastic/polymer materials rated for use with carbon dioxide and compliant with *Code of Federal Regulations Title 21 FDA Part 177 Indirect Food Additives Polymers*.
5. Additional approved piping, tubing and hoses found in the Compressed Gas Association (CGA) standards for carbon dioxide

5307.3.2.1.1 Support. Gas piping shall not be attached or supported by any electrical light supports or wiring.

5307.3.2.1.2 Identification. Markings for carbon dioxide (CO₂) piping systems shall consist of the content's name (carbon dioxide or CO₂) and direction-of-flow arrow. Markings shall be provided at each valve; at wall, floor or ceiling penetrations; at each change of direction; and at not less than every 20 feet or fraction thereof throughout the piping run.

5307.3.2.2 Fittings, joints and connections. Fittings, joints and connections shall be subject to the approval of the fire and building departments.

5307.3.2.2.1 Fittings and joints between gas supply containers and automatic shutoff valve. Joints and fittings on the supply piping or tubing between the CO₂ supply source and the automatic system shutoff valve shall be threaded, compression or welded.

5307.3.2.2.2 Unused connections. Unused piping or tubing connected to the supply system shall be capped or plugged. A closed valve will not be allowed in lieu of a cap or plug.

5307.3.2.2.3 Concealed connections. All fittings and joints shall be exposed and located adjacent to the supply source or points of use and shall be protected by a detector.

5307.3.2.3 Valves. Piping systems shall be provided with valves in accordance with Sections 5307.3.2.3.1 through 5307.3.2.3.5.

5307.3.2.3.1 Pressure relief valves. Pressure relief valves shall be provided and piped to the outdoors.

5307.3.2.3.2 System shutoff valve. An automatic system shutoff valve shall be provided as near to the supply pressure regulator as possible and shall be designed to fail to a closed condition closing on loss of electrical power to the valve and gas detection. Automatic shutoff valves shall be designed and located so that all phases (i.e., gas, liquid and solid) of a carbon dioxide (CO₂) will not interfere with the operation of the device.

5307.3.2.3.3 Appliance shutoff valves. Each appliance shall be provided with a shutoff valve within 3 feet of the appliance. All shutoff valves shall be capable of being locked or tagged in the closed position for servicing.

5307.3.2.3.4 Check valves. One-way flow check valves shall be installed at the most downstream end of copper runs that are used for beverage consumption.

5307.3.2.3.5 Accessibility and identification. Valves and controls shall be readily accessible at all times. Normal and emergency system shut-off valves shall be clearly identified. All valves shall be designed or marked to indicate clearly whether it is open or closed.

5307.3.3 Venting. Venting of gases shall be directed to an approved location outside the building. Insulated liquid carbon dioxide systems shall have pressure relief devices vented in accordance with NFPA 55.

5307.4 Protection from damage. Carbon dioxide systems shall be installed so the storage tanks, cylinders, piping and fittings are protected from damage by occupants or equipment during normal facility operations.

5307.5 Required protection. Where carbon dioxide storage tanks, cylinders, piping and equipment are located indoors, rooms or areas containing carbon dioxide storage tanks, cylinders, piping and fittings and other areas where a leak of a carbon dioxide system can collect shall be provided with either ventilation in accordance with Section 5307.5.1 or an emergency alarm system in accordance with Section 5307.5.2.

5307.5.1 Ventilation. Mechanical ventilation shall be in accordance with the *International Mechanical Code* and shall comply with all of the following:

1. Mechanical ventilation in the room or area shall be at a rate of not less than 1 cubic foot per minute per square foot [$0.00508 \text{ m}^3/(\text{s} \cdot \text{m}^2)$].
2. Exhaust shall be taken from a point within 12 inches (305 mm) of the floor.
3. The ventilation system shall be designed to operate at a negative pressure in relation to the surrounding area.
4. Ventilation shall run continuously or be activated by a sensor or detector to maintain an atmosphere of less than 5,000 ppm.
5. A mechanical permit is required in accordance with the Denver Building Code.

5307.5.2 Emergency alarm system. An emergency alarm system shall comply with all of the following:

1. Continuous gas detection shall be provided to monitor areas where carbon dioxide (CO₂) can accumulate. Detection equipment shall be provided to indicate carbon dioxide (CO₂) levels at each point of use and in each storage area/room.
2. Detectors shall be:
 - a. listed or approved devices
 - b. permanently mounted
 - c. installed at a height of between 12 - 24 inches above the floor or as approved by the fire code official
 - d. directly connected to building electrical and fire alarm systems and protected from accidental disconnection or damage
 - e. auto calibrating and self “zeroing” devices are not permitted unless they can be zeroed and spanned
 - f. located within manufacturers specified detection range for each point of use and storage location
3. Alarm set points shall be set at:
 - a. 5,000 PPM (TWA) Time Weighted Average – Self re-setting (non-latching) alarm

- Notification for employees only in approved locations with instructional signage
- b. 15,000 PPM – Latching Alarm
- Notification for employees only in approved locations
 - Requires a service company or approved trained employees to investigate, repair and reset
- c. 30,000 PPM – Latching Alarm
- Initiate amber strobes and audible horns provided in the vicinity of each interior storage container, cylinder or tank and at each point of use. Additional amber strobes and audible horns shall be placed at the entrances to below grade locations, confined spaces, and at walk-in coolers. The notification devices shall be rated a minimum of 80cd for a visible effect and 75 dBA for an audible effect and shall be mounted in accordance with NFPA 72 requirements.
 - Activation of automatic system shutoff valve
 - Evacuate room/area and call 911
 - Alarm Signal*

*In buildings with a monitored sprinkler or fire alarm/detection system, the carbon dioxide (CO₂) emergency alarm system shall be connected to the building fire alarm control panel. A fire alarm permit is required in accordance with the *Denver Building Code*.

4. Signage shall be required adjacent to each horn/strobe as follows:

Outside the storage or point of use area/room: “DO NOT ENTER WHEN LIGHT IS FLASHING - CARBON DIOXIDE LEAK DETECTED – CALL 911”

Inside the storage or point of use area/room: “FLASHING LIGHT MEANS CARBON DIOXIDE LEAK DETECTED – EVACUATE IMMEDIATELY AND CALL 911”

The sign shall have a minimum 1-inch block lettering with a minimum ¼-inch stroke. The sign shall be on a contrasting surface of black on yellow and shall be of durable construction.

Additional warning signs shall be posted at the entrances to a room or confined area where the container is located. The warning sign shall be at least 8 inches (200 mm) wide and 6 inches (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 704 placards for Simple Asphyxiants shall also be provided at the main entrance to storage rooms, areas or confined spaces.

5307.6 Transfilling. Filling and transfilling of gases between storage containers, cylinders and tanks and delivery vehicles shall be performed by qualified personnel using equipment and operating procedures in accordance with CGA P-1. Interior storage containers, cylinders and tanks shall be filled via remote fill ports on the exterior of the building at grade level. Exterior remote fill ports shall be fitted with a vent line to the outside. Delivery personnel shall have access to interior storage areas to inspect valves and piping prior to initiating filling operations.

5307.7 Inspection and testing. All piping installations shall be visually inspected, calibrated, and pressure tested to determine that the materials, design, fabrication and installation practices comply with the requirements of this code.

5307.7.1 Records. A written record of all required inspections, testing, calibration, and maintenance shall be maintained in a log book on the premises containing the three (3) most current years of records and be available for review by fire inspection personnel.

5307.7.2 Required inspections and testing. All piping installations shall be tested and inspected in accordance with Sections 5307.7.2.1 through 5307.7.2.5.

5307.7.2.1 Acceptance testing. Appliances and equipment shall not be placed in operation until after the piping system has been checked for leakage and detectors, notification devices and automatic shutoff valves have been tested by a qualified service company. All piping installations shall be visually inspected and pressure tested prior to initial operation. The test pressure downstream of the pressure regulator shall be not less than 110% of the operating pressure. Joints shall be checked with a bubble-forming solution. Acceptance testing is required to be witnessed by Fire and/or Building Code Officials. Provide an inspection report to the fire and/or building officials for the piping and joint visual inspection and pressure test.

5307.7.2.2 Daily inspections. All detectors and alarms shall be visibly inspected daily. These inspections are permitted to be conducted by trained employees.

5307.7.2.3 Monthly inspections. All storage vessels, piping, and appurtenances shall be visibly inspected monthly. These inspections are permitted to be conducted by trained employees.

5307.7.2.4 Semi-annual inspections. Systems shall be visually inspected, gas detectors calibrated in accordance with manufacturer specification, alarms tested, and tested for leaks semi-annually by a qualified service company.

5307.7.2.5 Alterations and repair. In the event alterations, repairs or additions are made, the affected piping shall be retested in accordance with Section 5307.7.2.1.

5307.7.3 Reserved.

5307.7.4 Calibration. Detectors shall be checked for accuracy, calibrated to a reference gas concentration, and span reset.

5307.7.5 Pressure testing. Pipe joints shall be exposed for examination during the test.

5307.7.5.1 Test medium. The test medium shall be air, nitrogen, carbon dioxide, or an inert gas.

5307.7.5.2 Section testing. Piping systems shall be permitted to be tested as a complete unit or in sections. A valve shall not be subjected to the test pressure unless it can be determined that the valve, including the valve-closing mechanism, is designed to safely withstand the test pressure.

5307.7.5.3 Regulators and valve assemblies. Regulator and valve assemblies fabricated independently of the piping systems in which they are to be installed shall be permitted to be tested with inert gas or air at the time of fabrication. Test records shall be maintained in accordance with Section 5307.7.1.

5307.7.5.4 Test preparation. All joints and fittings shall be exposed for examination during and after the test.

5307.7.5.4.1 Pipe clearing. Prior to testing, the interior of the pipe shall be cleared of all foreign material.

5307.7.5.4.2 Appliance and equipment isolation. Appliances and equipment that are not to be included in the test shall be isolated from the piping by closing the appliance shutoff valve.

5307.7.5.4.3 Test pressure measurement. Test pressure shall be measured with a pressure-measuring device designed and calibrated to read, record or indicate a pressure loss caused by leakage during the pressure test period. The source of pressure shall be isolated before the pressure tests are made. Mechanical gauges used to measure test pressures shall have a range such that the highest end of the scale is not greater than five times the test pressure.

5307.7.5.4.4 Test pressure. The test pressures shall be as specified in Section 5307.7.2.1. Where the test pressure exceeds 125 psig (862 kPa gauge), the test pressure shall not exceed a value that produces a hoop stress in the piping greater than 50 percent of the specified minimum yield strength of the pipe or tubing. Pressures shall be adjusted smoothly and slowly to avoid pressure spikes.

5307.7.5.5 Test duration. The test duration shall be not less than 10 minutes.

5307.7.5.6 Visual inspection and cleaning. After testing is complete and the pressure is reduced to at or below operating pressure, all joints shall be cleaned of bubble-forming solution and visually inspected

5307.7.5.7 Detection of leaks and defects. The piping system shall withstand the test pressure specified without showing any evidence of leakage or other defects. Any reduction of test pressures as indicated by pressure gauges shall be deemed to indicate the presence of a leak.

5307.7.5.8 Corrections. Where leakage or other defects are located, the affected portion of the piping system shall be repaired or replaced and retested.

5307.8 Training. All employees shall receive annual training in hazard identification, physical properties, inspection, and emergency procedures. Training records shall be maintained on site and be available to fire inspectors upon request.

Section 5309 Inert Gas Systems Used in Commercial, Manufacturing or Industrial Applications is added as follows:

SECTION 5309

INERT GAS SYSTEMS USED IN COMMERCIAL, MANUFACTURING OR INDUSTRIAL APPLICATIONS

5309.1 General. Inert gas systems with more than 100 pounds (45.4 kg) of an inert gas or any system using any amount of an inert gas below grade used in a commercial, manufacturing or industrial application, such as water treatment with pH balancing, food processing or laboratories shall comply with Sections 5309.1 through 5309.8. Inert gases include but are not limited to argon, helium, nitrogen and carbon dioxide. Provisions of Section 5307 are applicable where CO₂ is used.

Exceptions:

1. Medical gas systems
2. Gaseous Fire suppression systems
3. Carbon dioxide gas enrichment systems in accordance with Section 5310

5309.2 Permits. Permits shall be required in accordance with Sections 105 and in accordance with Denver Fire Department policy.

5309.3 Equipment. The storage, use, and handling of inert gases shall be in accordance with IFC Chapters 53 and 55, as amended, and the applicable requirements of NFPA 55. All equipment utilized in compressed gas systems shall be compatible with the intended gas and use.

5309.3.1 Containers, cylinders and tanks. Gas storage containers, cylinders and tanks shall be designed, fabricated, tested and labeled with manufactures' specifications and shall be maintained in accordance with the regulations of DOTn 49 CFR, Parts 100-185 or the ASME *Boiler and Pressure Vessel Code*, Section VIII.

5309.3.1.1 Location. Location of gas storage containers, cylinders and tanks, inside or outside the building, shall be at an approved location.

5309.3.1.2 Security. Gas storage containers, cylinders and tanks shall be secured in an approved manner to prevent overturning. Containers, cylinders and tanks located outside shall be secured and safeguarded against tampering and protected from physical damage if exposed to vehicle traffic.

5309.3.1.3 Design and construction. Bulk tank installations over 2,000 pounds will require an engineered foundation and construction permit in accordance with the *Denver Building Code*.

5309.3.2 Piping systems. Piping, tubing, fittings, valves and pressure regulating devices shall be designed and installed in accordance with approved standards and manufacturers' recommendations. PVC/ABS and other types of rigid plastic piping are not approved materials. Piping systems shall be marked in accordance with Chapter 53. Valves and controls shall be readily accessible at all times. Normal and emergency shut-off valves shall be clearly identified. Pressure relief valves shall be provided and piped to the outdoors. Each appliance or piece of equipment shall be provided with a shutoff valve within 3 feet of the appliance or piece of equipment. Automatic system shutoff valves shall be provided as near to the supply pressure regulator or container as possible and designed to fail to a closed condition closing on loss of electrical power to the valve and gas detection. All valves shall be designed or marked to indicate clearly whether it is open or closed. All fittings and joints shall be exposed and located adjacent to the supply source or points of use and shall be protected by a detector.

5309.3.3 Venting. Venting of gases shall be directed to an approved location outside the building. Insulated liquid gas systems shall have pressure relief devices vented in accordance with NFPA 55.

5309.4 Protection from damage. Inert gas systems shall be installed so the storage tanks, cylinders, piping and fittings are protected from damage by occupants or equipment during normal facility operations.

5309.5 Required protection. Where inert gas storage tanks, cylinders, piping and equipment are located indoors, rooms or areas containing inert gas storage tanks, cylinders, piping and fittings and other areas where a leak of an inert gas system can collect shall be provided with either ventilation in accordance with Section 5309.5.1 or an emergency alarm system in accordance with Section 5309.5.2.

5309.5.1 Ventilation. Mechanical ventilation shall be in accordance with the *International Mechanical Code* and shall comply with all of the following:

1. Mechanical ventilation in the room or area shall be at a rate of not less than 1 cubic foot per minute per square foot [$0.00508 \text{ m}^3/(\text{s} \cdot \text{m}^2)$].
2. Exhaust ventilation shall be designed to consider the density of the potential vapors released. For vapors that are heavier than air, exhaust shall be taken from a point within 12 inches (305 mm) of the floor. For 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.
3. The ventilation system shall be designed to operate at a negative pressure in relation to the surrounding area.
4. Ventilation shall run continuously or be activated by a sensor or detector to maintain an atmosphere of not less than 19.5% oxygen in the room.
5. A mechanical permit is required in accordance with the *Denver Building Code*.

5309.5.2 Emergency alarm system. An emergency alarm system shall comply with all of the following:

1. Continuous gas detection shall be provided to monitor areas where a leak of an inert gas system can collect and create an oxygen deficient atmosphere. Detection equipment shall be provided at each point of use and in each storage area/room.
2. Detectors shall be:
 - a. listed or approved devices
 - b. permanently mounted
 - c. installed at a height consistent with the vapor density of the gas
 - d. directly connected to the building electrical supply and fire alarm system and protected from accidental disconnection or damage
 - e. auto calibrating and self “zeroing” devices are not permitted unless they can be zeroed and spanned
 - f. located within manufactures’ specified detection range for each point of use and storage location
3. Activation of the emergency alarm system shall initiate amber strobes and audible horns provided in the vicinity of each interior storage container, cylinder or tank and at each point of use in accordance with alarm set points. Additional amber strobes and audible horns shall also be placed at the entrances to below grade locations and confined spaces. The notification devices shall be rated a minimum of 80cd

for a visible effect and 75 dBA for an audible effect and shall be mounted in accordance with NFPA 72 requirements.

4. Alarm set points shall be set at:
 - a. Oxygen levels below 19.5% – Self re-setting (non-latching) alarm
 - Visual notification only in approved locations
 - b. Oxygen levels below 17% – Latching Alarm
 - Visual and audible notification in approved locations
 - Activation of automatic system shutoff valve
 - Evacuate room/area and call 911
 - Alarm signal*

*In buildings with a monitored sprinkler or fire alarm/detection system, the inert gas emergency alarm system shall be connected to the building fire alarm control panel. A fire alarm permit is required in accordance with the *Denver Building Code*.

5. Signage shall be required adjacent to each horn/strobe as follows.

Outside the Storage Area/Room: **“DO NOT ENTER WHEN LIGHT IS FLASHING – OXYGEN DEFICIENT ATMOSPHERE DETECTED – CALL 911”**

Inside the Storage Area/Room or at point of use: **“FLASHING LIGHT MEANS OXYGEN DEFICIENT ATMOSPHERE DETECTED – EVACUATE IMMEDIATELY AND CALL 911”**

The sign shall have a minimum 1-inch block lettering with a minimum ¼-inch stroke. The sign shall be on a contrasting surface of black on yellow and shall be of durable construction.

On the door of the Storage Room: Signage shall be provided on each storage area entry door stating:



NFPA 704 placards for simple asphyxiants shall also be provided at the main entrance to storage rooms/areas.

5309.6 Transfilling. Filling and transfilling of gases between storage containers, cylinders and tanks and delivery vehicles shall be performed by qualified personnel using equipment and operating procedures in accordance with

CGA P-1. Interior storage containers, cylinders and tanks shall be filled via remote fill ports on the exterior of the building at grade level. Exterior remote fill ports shall be fitted with a vent line to the outside. Delivery personnel shall have access to interior storage areas to inspect valves and piping prior to initiating filling operations.

5309.7 Inspection and testing. All piping installations shall be visually inspected, calibrated, and pressure tested to determine that the materials, design, fabrication and installation practices comply with the requirements of this code.

5309.7.1 Records. A written record of all required inspections, testing, calibration, and maintenance shall be maintained in a log book on the premises containing the three most current years of records and be available for review by fire inspection personnel.

5309.7.2 Required inspections and testing. All piping installations shall be tested and inspected in accordance with Sections 5309.7.2.1 through 5309.7.2.5.

5309.7.2.1 Acceptance testing. Appliances and equipment shall not be placed in operation until after the piping system has been checked for leakage and detectors, notification devices and automatic shutoff valves have been tested by a qualified service company. All piping installations shall be visually inspected and pressure tested prior to initial operation. The test pressure downstream of the pressure regulator shall be not less than 1½ times the proposed operating pressure. Joints shall be checked with a bubble-forming solution. Acceptance testing is required to be witnessed by Fire and/or Building Code Officials. Provide an inspection report to the fire and/or building officials for the piping and joint visual inspection and pressure test.

5309.7.2.2 Daily inspections. All detectors and alarms shall be visibly inspected daily. These inspections are permitted to be conducted by trained employees.

5309.7.2.3 Monthly inspections. All storage vessels, piping, and appurtenances shall be visibly inspected monthly. These inspections are permitted to be conducted by trained employees.

5309.7.2.4 Semi-annual inspections. Systems shall be visually inspected, gas detectors calibrated in accordance with manufacturer specification, alarms tested, and tested for leaks semi-annually by a qualified service company.

5309.7.2.5 Alterations and repair. In the event alterations, repairs or additions are made, the affected piping shall be retested in accordance with Section 5309.7.2.1.

5309.7.3 Reserved.

5309.7.4 Calibration. Detectors shall be checked for accuracy, calibrated to a reference gas concentration, and span reset.

5309.7.5 Pressure testing. Pipe joints shall be exposed for examination during the test.

5309.7.5.1 Test medium. The test medium shall be air, nitrogen, carbon dioxide, or an inert gas.

5309.7.5.2 Section testing. Piping systems shall be permitted to be tested as a complete unit or in sections. A valve shall not be subjected to the test pressure unless it can be determined that the valve, including the valve-closing mechanism, is designed to safely withstand the test pressure.

5309.7.5.3 Regulators and valve assemblies. Regulator and valve assemblies fabricated independently of the piping systems in which they are to be installed shall be permitted to be tested with inert gas or air at the time of fabrication. Test records shall be maintained in accordance with Section 5309.7.1.

5309.7.5.4 Test preparation. All joints and fittings shall be exposed for examination during and after the test.

5309.7.5.4.1 Pipe clearing. Prior to testing, the interior of the pipe shall be cleared of all foreign material.

5309.7.5.4.2 Appliance and equipment isolation. Appliances and equipment that are not to be included in the test shall be disconnected from the piping by closing the isolation shutoff valve.

5309.7.5.4.3 Test pressure measurement. Test pressure shall be measured with a pressure-measuring device designed and calibrated to read, record or indicate a pressure loss caused by leakage during the pressure test period. The source of pressure shall be isolated before the pressure tests are made. Mechanical gauges used to measure test pressures shall have a range such that the highest end of the scale is not greater than five times the test pressure.

5309.7.5.4.4 Test pressure. The test pressures shall be as specified in Section 5309.7.2.1. Where the test pressure exceeds 125 psig (862 kPa gauge), the test pressure shall not exceed a value that produces a hoop stress in the piping greater than 50 percent of the specified minimum yield strength of the pipe or tubing. Pressures shall be adjusted smoothly and slowly to avoid pressure spikes.

5309.7.5.5 Test duration. The test duration shall be not less than 1/2 hour for each 500 cubic feet (14 m³) of pipe volume or fraction thereof. When testing a system having a volume less than 10 cubic feet (0.28 m³) the test duration shall be not less than 10 minutes. The duration of the test shall not be required to exceed 24 hours.

5309.7.5.6 Visual inspection and cleaning. After testing is complete and the pressure is reduced to at or below operating pressure, all joints shall be cleaned of bubble-forming solution and visually inspected

5309.7.5.7 Detection of leaks and defects. The piping system shall withstand the test pressure specified without showing any evidence of leakage or other defects. Any reduction of test pressures as indicated by pressure gauges shall be deemed to indicate the presence of a leak.

5309.7.5.8 Corrections. Where leakage or other defects are located, the affected portion of the piping system shall be repaired or replaced and retested.

5309.8 Training. All employees shall receive annual training in hazard identification, physical properties, inspection, and emergency procedures. Training records shall be maintained on site and be available to inspectors upon request.

Section 5310 Carbon Dioxide (CO₂) gas enrichment systems using on-site supply tanks and/or cylinders in plant growing (husbandry) applications is added as follows:

SECTION 5310

CARBON DIOXIDE (CO₂) GAS ENRICHMENT SYSTEMS USING ON-SITE SUPPLY TANKS AND/OR CYLINDERS IN PLANT GROWING (HUSBANDRY) APPLICATIONS

5310.1 General. Carbon dioxide enrichment systems with more than 100 pounds (45.4 kg) of carbon dioxide or any system using any amount of carbon dioxide (CO₂) below grade used in plant growing (husbandry) applications shall comply with Sections 5310.2 through 5310.8.

5310.2 Permits. Permits shall be required in accordance with Sections 105 and in accordance with Denver Fire Department policy.

5310.3 Equipment. The storage, use, and handling of carbon dioxide shall be in accordance with IFC Chapter 53, as amended, and the applicable requirements of NFPA 55, Chapter 13. All equipment utilized in compressed gas systems shall be compatible with the intended gas and use.

5310.3.1 Containers, cylinders and tanks. Gas storage containers, cylinders and tanks shall be designed, fabricated, tested and labeled with manufactures' specifications and shall be maintained in accordance with the regulations of DOTn 49 CFR, Parts 100-185 or the ASME Boiler and Pressure Vessel Code, Section VIII.

5310.3.1.1 Location. Location of gas storage containers, cylinders and tanks, inside or outside the building, shall be at an approved location.

5310.3.1.2 Security. Gas storage containers, cylinders and tanks shall be secured in an approved manner to prevent overturning. Containers, cylinders and tanks located outside shall be secured and safeguarded against tampering and protected from physical damage if exposed to vehicle traffic.

5310.3.1.3 Design and construction. Bulk tank installations over 2,000 pounds will require an engineered foundation and construction permit in accordance with the Denver Building Code.

5310.3.2 Piping systems. Piping, tubing, fittings, valves and pressure regulating devices shall be designed and installed in accordance with approved standards and manufacturers' recommendations.

5310.3.2.1 Piping, tubing and hoses. Piping, tubing and hose materials shall be compatible with carbon dioxide and rated for the temperatures and pressures encountered in the system. All hoses and tubing used in carbon dioxide service shall be designed for a bursting pressure of at least four times their design pressure. PVC/ABS and other types of rigid plastic piping are not approved materials. Acceptable piping for carbon dioxide shall be the following:

- a. Stainless steel A269 grade, which is either seamless or welded drawn over mandrel
- b. Copper K grade, hard drawn seamless
- c. Copper ACR grade (1/2 inch outside diameter or less) annealed seamless
- d. Plastic/polymer materials rated for use with carbon dioxide

- e. Additional approved piping, tubing and hoses found in the Compressed Gas Association (CGA) standards for carbon dioxide

5310.3.2.1.1 Support. Gas piping shall not be attached or supported by any electrical light supports or wiring.

5310.3.2.1.2 Identification. Markings for carbon dioxide (CO₂) piping systems shall consist of the content's name (carbon dioxide or CO₂) and direction-of-flow arrow. Markings shall be provided at each valve; at wall, floor or ceiling penetrations; at each change of direction; and at not less than every 20 feet or fraction thereof throughout the piping run.

5310.3.2.2 Fittings, joints and connections. Fittings, joints and connections shall be subject to the approval of the fire and building departments.

5310.3.2.2.1 Fittings and joints between gas supply containers and automatic shutoff valve. Joints and fittings on the supply piping or tubing between the CO₂ supply source and the automatic system shutoff valve shall be threaded, compression or welded.

5310.3.2.2.2 Unused connections. Unused piping or tubing connected to the supply system shall be capped or plugged. A closed valve will not be allowed in lieu of a cap or plug.

5310.3.2.2.3 Concealed connections. All fittings and joints shall be exposed and located adjacent to the supply source or points of use and shall be protected by a detector.

5310.3.2.3 Valves. Piping systems shall be provided with valves in accordance with Sections 5307.3.2.3.1 through 5307.3.2.3.4.

5310.3.2.3.1 Pressure relief valves. Pressure relief valves shall be provided and piped to the outdoors.

5310.3.2.3.2 System shutoff valve. An automatic system shutoff valve shall be provided as near to the supply pressure regulator as possible and shall be designed to fail to a closed condition closing on loss of electrical power to the valve and gas detection. Additional automatic shutoff valves may be provided at each point of use. Automatic shutoff valves shall be designed and located so that all phases (i.e., gas, liquid and solid) of carbon dioxide (CO₂) will not interfere with the operation of the device.

5310.3.2.3.3 Appliance shutoff valves. Each appliance shall be provided with a shutoff valve within 3 feet of the appliance. All shutoff valves shall be capable of being locked or tagged in the closed position for servicing.

5310.3.2.3.4 Accessibility and identification. Valves and controls shall be readily accessible at all times. Normal and emergency system shut-off valves shall be clearly identified. All valves shall be designed or marked to indicate clearly whether it is open or closed.

5310.3.3 Venting. Venting of gases shall be directed to an approved location outside the building. Insulated liquid carbon dioxide systems shall have pressure relief devices vented in accordance with NFPA 55.

5310.4 Protection from damage. Carbon dioxide systems shall be installed so the storage tanks, cylinders, piping and fittings are protected from damage by occupants or equipment during normal facility operations.

5310.5 Required protection. Where carbon dioxide storage tanks, cylinders, piping and equipment are located indoors, rooms or areas containing carbon dioxide storage tanks, cylinders, piping and fittings and grow room/areas

where carbon dioxide is released and can collect shall be provided with an emergency alarm system in accordance with Section 5310.5.1.

5310.5.1 Emergency alarm system. An emergency alarm system shall comply with all of the following:

1. Continuous gas detection shall be provided to monitor areas where carbon dioxide (CO₂) can accumulate. Detection equipment shall be provided to indicate carbon dioxide (CO₂) levels in each grow cultivation area/room and interior carbon dioxide (CO₂) storage location.
2. Detectors shall be:
 - a. listed or approved devices
 - b. permanently mounted
 - c. installed at a height of no more than 48 inches above the floor or as approved by the fire code official
 - d. directly connected to building electrical supply and ~~or~~ fire alarm systems and protected from accidental disconnection or damage
 - e. auto calibrating and self “zeroing” devices are not permitted unless they can be zeroed and spanned
 - f. located within manufacturers specified detection range for each point of use and storage location
3. Activation of the emergency alarm system shall initiate amber strobes and audible horns provided in the vicinity of each interior storage container, cylinder or tank and at each point of release. Additional amber strobes and audible horns shall be placed at the entrances to below grade locations and confined spaces. The notification devices shall be rated a minimum of 80cd for a visible effect and 75 dBA for an audible effect and shall be mounted in accordance with NFPA 72 requirements. Provide audible visual devices at the following locations:
 - Inside an interior storage room/area and outside the room/area at each entrance.
 - Inside grow cultivation room/areas.
4. Local alarm set points shall be set at:
 - a. 5,000 PPM – Latching Alarm
 - Visual and audible notification in approved locations at room or area in alarm
 - Activation of automatic system shut off valve
 - Evacuate the room in alarm and contact a qualified service company to investigate and address the condition.
 - Reset of the emergency alarm to be conducted by qualified personnel.
5. Signage shall be required adjacent to each horn/strobe as follows.

Storage area/room: **“DO NOT ENTER WHEN LIGHT IS FLASHING - CARBON DIOXIDE LEAK DETECTED”**

Grow cultivation room/area dispensing: **“FLASHING LIGHT MEANS CARBON DIOXIDE LEAK DETECTED – EVACUATE ROOM”**

The sign shall have a minimum 1-inch block lettering with a minimum ¼ -inch stroke. The sign shall be on a contrasting surface of black on yellow and shall be of durable construction.

Signage on entrance doors to grow cultivation and storage rooms: Signage shall be provided at entrance doors to each grow cultivation room/area and at each entrance to storage rooms/areas:



NFPA 704 placards for simple asphyxiants shall also be provided at the exterior main entrance and at each entrance to storage rooms/areas.

6. A minimum of one portable carbon dioxide (CO₂) meter shall be in use during business hours.

5310.6 Transfilling. Filling and transfilling of gases between storage containers, cylinders and tanks and delivery vehicles shall be performed by qualified personnel using equipment and operating procedures in accordance with CGA P-1. Interior storage containers, cylinders and tanks shall be filled via remote fill ports on the exterior of the building at grade level. Exterior remote fill ports shall be fitted with a vent line to the outside. Delivery personnel shall have access to interior storage areas to inspect valves and piping prior to initiating filling operations.

5310.7 Inspection and testing. All piping installations shall be visually inspected, calibrated, and pressure tested to determine that the materials, design, fabrication and installation practices comply with the requirements of this code.

5310.7.1 Records. A written record of all required inspections, testing, calibration, and maintenance shall be maintained in a log book on the premises containing the three (3) most current years of records and be available for review by fire inspection personnel.

5310.7.2 Required inspections and testing. All piping installations shall be tested and inspected in accordance with Sections 5310.7.2.1 through 5310.7.2.5.

5310.7.2.1 Acceptance testing. Appliances and equipment shall not be placed in operation until after the piping system has been checked for leakage and detectors, notification devices and automatic shutoff valves have been tested by a qualified service company. All piping installations shall be visually inspected and pressure tested prior to initial operation. The test pressure downstream of the pressure regulator shall be not less than 110% of the operating pressure. Joints shall be checked with a bubble-forming solution. Acceptance testing is required to be witnessed by Fire and/or Building Code Officials. Provide an inspection report to the fire and/or building officials for the piping and joint visual inspection and pressure test.

5310.7.2.2 Daily inspections. All detectors and alarms shall be visibly inspected daily. These inspections are permitted to be conducted by trained employees.

5310.7.2.3 Monthly inspections. All storage vessels, piping, and appurtenances shall be visibly inspected monthly. These inspections are permitted to be conducted by trained employees.

5310.7.2.4 Semi-annual inspections. Systems shall be visually inspected, gas detectors calibrated in accordance with manufacturer specification, alarms tested, and tested for leaks semi-annually by a qualified service company.

5310.7.2.5 Alterations and repair. In the event alterations, repairs or additions are made, the affected piping shall be retested in accordance with Section 5310.7.2.1.

5310.7.3 Reserved.

5310.7.4 Calibration. Detectors shall be checked for accuracy, calibrated to a reference gas concentration, and span reset.

5310.7.5 Pressure testing. Pipe joints shall be exposed for examination during the test.

5310.7.5.1 Test medium. The test medium shall be air, nitrogen, carbon dioxide, or an inert gas.

5310.7.5.2 Section testing. Piping systems shall be permitted to be tested as a complete unit or in sections. A valve shall not be subjected to the test pressure unless it can be determined that the valve, including the valve-closing mechanism, is designed to safely withstand the test pressure.

5310.7.5.3 Regulators and valve assemblies. Regulator and valve assemblies fabricated independently of the piping systems in which they are to be installed shall be permitted to be tested with inert gas or air at the time of fabrication. Test records shall be maintained in accordance with Section 5310.7.1.

5310.7.5.4 Test preparation. All joints and fittings shall be exposed for examination during and after the test.

5310.7.5.4.1 Pipe clearing. Prior to testing, the interior of the pipe shall be cleared of all foreign material.

5310.7.5.4.2 Appliance and equipment isolation. Appliances and equipment that are not to be included in the test shall be isolated from the piping by closing the appliance shutoff valve.

5310.7.5.4.3 Test pressure measurement. Test pressure shall be measured with a pressure-measuring device designed and calibrated to read, record or indicate a pressure loss caused by leakage during the pressure test period. The source of pressure shall be isolated before the pressure tests are made. Mechanical gauges used to measure test pressures shall have a range such that the highest end of the scale is not greater than five times the test pressure.

5310.7.5.4.4 Test pressure. The test pressures shall be as specified in Section 5310.7.2.1. Where the test pressure exceeds 125 psig (862 kPa gauge), the test pressure shall not exceed a value that produces a hoop stress in the piping greater than 50 percent of the specified minimum yield strength of the pipe or tubing. Pressures shall be adjusted smoothly and slowly to avoid pressure spikes.

5310.7.5.5 Test duration. The test duration shall be not less than 10 minutes.

5310.7.5.6 Visual inspection and cleaning. After testing is complete and the pressure is reduced to at or below operating pressure, all joints shall be cleaned of bubble-forming solution and visually inspected.

5310.7.5.7 Detection of leaks and defects. The piping system shall withstand the test pressure specified without showing any evidence of leakage or other defects. Any reduction of test pressures as indicated by pressure gauges shall be deemed to indicate the presence of a leak.

5310.7.5.8 Corrections. Where leakage or other defects are located, the affected portion of the piping system shall be repaired or replaced and retested.

5310.8 Training. All employees shall receive annual training in hazard identification, physical properties, inspections, and emergency procedures. Training records shall be maintained on site and be available to inspectors upon request.

Section 5311 Carbon Dioxide (CO₂) Gas Enrichment Systems Using a Natural Gas Burner in Plant Growing (Husbandry) Applications is added as follows:

SECTION 5311

CARBON DIOXIDE (CO₂) GAS ENRICHMENT SYSTEMS USING A NATURAL GAS BURNER IN PLANT GROWING (HUSBANDRY) APPLICATIONS

5311.1 General. Natural gas burners that are utilized to generate carbon dioxide (CO₂) in plant growing (husbandry) applications shall comply with Sections 5311.2 through 5311.6. A mechanical exhaust system shall be provided as required by the *International Mechanical Code*.

5311.2 Permits. Permits shall be required in accordance with Section 105 and in accordance with Denver Fire Department policy.

5311.3 Equipment. Natural gas burners shall be listed, labeled and installed in accordance with the manufacturer's installation instructions. Piping systems, combustion and ventilation air and venting for natural gas appliances shall be designed and installed in accordance with approved standards, the International Fuel Gas Code and manufacturer's recommendations.

5311.4 Required protection. Where natural gas burners are located indoors for carbon dioxide (CO₂) enrichment, grow room/areas shall be provided with an emergency alarm system in accordance with Section 5311.4.1 and carbon monoxide detection in accordance with Section 5311.4.2.

5311.4.1 Emergency alarm system. An emergency alarm system shall comply with all of the following:

1. Continuous gas detection shall be provided to monitor areas where carbon dioxide (CO₂) can accumulate. Detection equipment shall be provided to indicate carbon dioxide (CO₂) levels in each grow cultivation area/room.
2. Detectors shall be:
 - a. listed or approved devices

- b. permanently mounted
 - c. installed at a height of no more than 48 inches above the floor or as approved by the fire code official
 - d. directly connected to building electrical supply and ~~or~~ fire alarm systems and protected from accidental disconnection or damage
 - e. auto calibrating and self “zeroing” devices are not permitted unless they can be zeroed and spanned
 - f. located within manufacturer’s specified detection range for each point of release
3. Activation of the emergency alarm system shall initiate amber strobes and audible horns provided in each room/area where carbon dioxide (CO₂) can accumulate. Additional amber strobes and audible horns shall be placed at the entrances to below grade locations. The notification devices shall be rated a minimum of 80cd for a visible effect and 75 dBA for an audible effect and shall be mounted in accordance with NFPA 72 requirements. Provide notification devices at the following locations:
- Inside grow cultivation room/areas.
4. Local alarm set points shall be set at:
- 5,000 PPM – Latching Alarm
- Visual and audible notification in approved locations at room or area in alarm
 - Activation of the automatic natural gas control valves to each burner to a closed position stopping the generation of carbon dioxide (CO₂)
 - Evacuate the room in alarm and contact a qualified service company.
 - Reset of emergency alarm to be conducted by qualified personnel.
5. Signage will be required adjacent to each horn/strobe as follows:

Entrance to below grade location: **“DO NOT ENTER WHEN LIGHT IS FLASHING – CARBON DIOXIDE LEAK DETECTED”**

Grow cultivation room/area dispensing: **“FLASHING LIGHT MEANS CARBON DIOXIDE LEAK DETECTED – EVACUATE ROOM”**

The sign shall have a minimum 1-inch block lettering with a minimum ¼ -inch stroke. The sign shall be on a contrasting surface of black on yellow and shall be of durable construction.

Signage at entrance doors: Signage shall be provided at entrance doors to each grow cultivation room/area:



NFPA 704 placards for simple asphyxiants shall also be provided at the exterior main entrance.

6. All carbon dioxide (CO₂) burner systems shall shut down in the event of a loss of electrical power to the carbon dioxide (CO₂) detectors.
7. A minimum of one (1) portable carbon dioxide (CO₂) meter shall be in use during business hours.

5311.4.2 Carbon monoxide (CO) detection.

1. Carbon monoxide (CO) gas detection shall be provided to monitor products of combustion continuously.
2. Detectors shall be:
 - a. listed or approved devices
 - b. permanently mounted
 - c. Installed per manufacturer's recommendations and directions
 - d. directly connected to building electrical supply and fire alarm systems and protected from accidental disconnection or damage
3. CO detection shall be set at 35 PPM and upon activation shall initiate the following:
 - Close the automatic valve to each burner
 - Activate the mechanical exhaust system
4. All carbon dioxide (CO₂) burner systems shall shut down in the event of a loss of electrical power to the carbon monoxide (CO) detectors.
5. A minimum of one (1) portable carbon monoxide (CO) meter shall be in use during business hours.

5311.5 Inspection and testing. All detectors, alarms and carbon dioxide (CO₂) burners must be visually inspected, calibrated, and tested to determine that the materials, design, fabrication and installation practices comply with the requirements of this code.

5311.5.1 Records. A written record of all required inspections, testing, calibration, and maintenance shall be maintained in a log book on the premises containing the three (3) most current years of records and be available for review by fire inspection personnel.

5311.5.2 Required inspections and testing. All detectors, alarms and carbon dioxide (CO₂) burner equipment shall be tested and inspected in accordance with Sections 5311.5.2.1 through 5311.5.2.6.

5311.5.2.1 Acceptance testing. Appliances and equipment shall not be placed in operation until after the detectors, notification devices, automatic gas control valves and mechanical exhaust system have been tested by a qualified service company. Acceptance testing is required to be witnessed by Fire and Building Code Officials.

5311.5.2.2 Daily inspections. All detectors and alarms shall be visibly inspected daily. These inspections are permitted to be conducted by trained employees.

5311.5.2.3 Monthly inspections. All carbon dioxide (CO₂) burners and appurtenances shall be visibly inspected monthly. These inspections are permitted to be conducted by trained employees.

5311.5.2.4 Semi-annual inspections. Systems shall be visually inspected and gas detectors calibrated in accordance with manufacturer specification semi-annually by a qualified service company.

5311.5.2.5 Annual testing. All detectors, alarms, gas control valves and mechanical exhaust systems shall be tested annually by a qualified service company.

5311.5.2.6 Alterations and repair. In the event alterations, repairs or additions are made, the affected equipment shall be retested in accordance with Section 5311.5.2.1.

5311.5.3 Reserved

5311.5.4 Calibration. Detectors shall be checked for accuracy, calibrated to a reference gas concentration, and span reset.

5311.6 Training. All employees shall receive annual training in hazard identification, physical properties, inspections, and emergency procedures. Training records shall be maintained on site and be available to inspectors upon request.