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1.0 Introduction

This quality guideline focuses on purity grade selection, transport, storage, dispensing and safe handling of carbon dioxide (CO₂) used in fountain beverage production. An expert international committee comprised of beverage manufacturers, CO₂ producers, supply chain vendors, analytical service providers, and in-line polisher/filter suppliers developed these guidelines based upon best available practices. This document is intended to serve as a valuable educational resource for fountain operators, beverage manufacturers, and all CO₂ supply chain vendors.

The function of dissolved CO₂ gas in beverages is to provide effervescence and some acidity without introducing any undesired sensory effects. As CO₂ is a key ingredient in many fountain products, CO₂ quality management is essential for ensuring consumer satisfaction.

These fountain guidelines are entirely consistent with the existing ISBT document, “Carbon Dioxide Quality Guidelines and Analytical Procedure Bibliography” that were intended for the proper manufacturing of packaged carbonated beverages (bottles and cans). Supplemental information is offered in this fountain document that is unique to the production of quality fountain beverages and the safe use of CO₂ at outlet sites.

*Beverage grade* CO₂, as defined in the “Carbon Dioxide Quality Guidelines and Analytical Procedure Bibliography”, is entirely acceptable for fountain consumption. Potential trace impurities present in this grade are well defined and related to common commercial sources and supplier purification capabilities. Because of the complex supply chain that is often required to deliver CO₂ to fountain facilities, additional contaminants may be introduced into a beverage grade CO₂ delivery by improper transport, storage or outlet dispensing practices. It is the responsibility of a CO₂ producer to identify, measure and control all listed impurities at acceptable levels in their final CO₂ product. Fountain CO₂ customers are responsible for ensuring that all of their CO₂ supply chain vendors follow good manufacturing and handling practices and have met their obligation to provide beverage grade CO₂ to their facilities. In addition, fountain operators should also recognize that poorly designed or maintained fountain hardware can degrade CO₂ quality within their outlets and that proper quality control actions must be taken to prevent such problems.

It is important to understand that some impurity guideline limits, per the “Carbon Dioxide Quality Guidelines and Analytical Procedure Bibliography”, relate to gas supplier purification capabilities or regulatory requirements. Many of the impurity guideline limits are based upon their known, negative sensory impact on a carbonated beverage. All beverage grade CO₂ quality guideline limits are readily measurable and achievable. Supply chain vendor protocol recommendations are offered to fountain operators regarding CO₂ quality traceability.

This document also includes useful information about common carbonation systems, operational and maintenance practices involving CO₂ mini-bulk tanks and gas cylinders along with a review of safe CO₂ handling practices (especially in confined spaces by fountain employees).

It is expected that these guidelines will assist the fountain industry in achieving compliance with many applicable international regulatory standards such as EU Council Directive 315/93/EEC, U.S. Good Manufacturing Practices (21 CFR 110), standards administered by Codex Alimentarius, as well as numerous local regulations.

The International Society of Beverage Technologists (ISBT) does not warrant the efficacy, accuracy, or completeness of these guidelines.
2.0 Acronyms / Definition of Terms

This section of the Guideline explains the acronyms used and defines the technical terms referenced herein. Wherever these acronyms and defined terms appear in this document they will be printed in italicized type.

2.1 Acronyms

2.1.1 ANSI
American National Standards Institute (U.S.)

2.1.2 ASME
American Society of Mechanical Engineers (U.S.)

2.1.3 CFR
Code of Federal Regulations (U.S.)

2.1.4 CGA
Compressed Gas Association

2.1.5 CO₂
Carbon dioxide

2.1.6 DOT
Department of Transportation (U.S.)

2.1.7 EIGA
European Industrial Gases Association

2.1.8 EEC
European Economic Community

2.1.9 EU
European Union (includes 25 member states)

2.1.10 FDA
Food and Drug Administration (U.S.)

2.1.11 HACCP
Hazard Analysis Critical Control Points: A systematic approach to the identification, evaluation, and control of product safety hazards.

2.1.12 ISBT
International Society of Beverage Technologists

2.1.13 ISO
International Standards Organization

2.1.14 NFPA
National Fire Protection Association (U.S.)

2.1.15 OSHA
Occupational Safety and Health Administration (U.S.)

2.1.16 TC
2.2 Definition of Terms

2.2.1 Asphyxiant
Any gas that can cause suffocation by displacing some or all of the oxygen normally present in ambient air.

2.2.2 Beverage Grade
A minimum carbon dioxide quality and purity designation for carbonated beverage applications based on the ISBT publication guideline “Carbon Dioxide Quality Guidelines and Analytical Procedure Bibliography.”

2.2.3 Boiling Point
The temperature at which the vapor pressure of a liquid equals the prevailing external pressure (e.g., boils). Carbon dioxide will boil at well below room temperature, so it exists only in the gas phase after equilibration under ambient conditions.

2.2.4 Carbonator
A standard piece of equipment that combines water with carbon dioxide to generate carbonated water for beverage supply in a typical fountain system.

2.2.5 Certificate of Analysis (CoA)
An official (signed) document verifying the actual analytical results of a specific sample of carbon dioxide product at a specific point in the supply chain.

2.2.5.1 The specific parameters analyzed for the CoA are usually defined under contract or by prior customer request.

2.2.5.2 A CoA provides direct verification of the quality of the sample tested for the parameters analyzed. Normally only provided by the supplier if specifically required under contract, or if requested by the customer prior to delivery, can also be provided by an independent third-party laboratory if necessary.

2.2.5.3 Since a CoA involves actual chemical analysis of the specific CO₂ sample, a CoA usually cannot be generated retroactively after delivery of product has occurred.

2.2.5.4 A CoA issued at a manufacturing plant may be used as a reference to generate a Certificate of Compliance (CoC) for deliveries from that location.

2.2.6 Certificate of Compliance (CoC)
(May also be described as a Certificate of Conformance) An official (signed) document that certifies a specific sample of carbon dioxide product meets a previously agreed upon quality specification based on quality procedures and handling of the material; but does not include actual data from analysis of the specific sample.

2.2.7 Compressed Gas
Any substance which, when enclosed in a container, gives a pressure reading of at least 25 psig at 70°F (21°C), or over 89 psig at 130°F (54°C), or over 25 psig at 100°F (38°C) for flammable materials.

2.2.8 Confined Space
An area that is 1) large enough and so configured that an employee can bodily enter and perform assigned work, 2) has limited or restricted means for entry or exit, and 3) is not designed for continuous employee occupancy. Improper carbon dioxide storage and usage in confined spaces can result in potentially hazardous situations.

2.2.9 Contaminant / Contamination
An undesirable component that may be found in the carbon dioxide and had been introduced after the CO₂ had been certified by the supplier. Contaminants may originate from some type of leak, mishandling of the product, or mistake occurring during the packaging and delivery process. Contamination can be avoided by following proper procedures and quality guidelines throughout the delivery process.

2.2.10 Flammability Rating
The National Fire Protection Association (NFPA) rating for carbon dioxide is zero (0), which indicates the material will not burn. This rating is found in the top (red) box of the NFPA Diamond (U.S.).

2.2.11 Fountain
1) Product forms which are dispensed and include; premix, postmix, dispensed juices, frozen carbonated beverages, and frozen non-carbonated beverages. 2) System used by retail outlets to dispense product into cups or glasses for immediate consumption.

2.2.12 Gas Cylinder / Cylinder
An un-insulated cylindrically shaped, pressure-containing device (see Figure 1 below) with a water capacity not greater than 120 U.S. Gal (454 L) designed to withstand an internal pressure greater than 40 psia (276 kPa, abs) as defined by DOT or TC [3,4].

Figure 1 – Gas Cylinder

2.2.13 Health Rating
The National Fire Protection Association (NFPA) rating for carbon dioxide is three (3), which indicates that the material can, on short exposure, cause serious temporary or residual injury. The rating is found in the left (blue) box of the NFPA Diamond (U.S.).

2.2.14 Impurity
An undesirable component that may be found in CO₂, coming from either the initial feed gas source or from the manufacturing process. Processing and purification of the feed gas CO₂ by the supplier should remove all impurities of concern before it is designated as finished product for delivery to customers. Undesired components that may be accidentally introduced to the product after this point are considered contaminants (see 2.2.9, above).

2.2.15 In-line CO₂ Filter/Polisher
An in-line CO₂ filter/polisher is a device that removes foreign matter from the working medium. An in-line filter/polisher could be installed in the gas line to prevent any impurities or contaminants from entering the beverage.

In-line CO₂ filters/polishers act as a final multi-layer barrier against trace impurities in a CO₂ gas supply. In addition, in-line filters/polishers also help protect beverage quality by removing trace contaminants that may have been introduced inadvertently during the storage and distribution of the gas from its source to the point of use.

2.2.16 Liquefied Compressed Gas
A gaseous component or mixture converted to the liquid phase by cooling or compression; also, any gas which remains partially liquid when placed in a container at 68ºF (20ºC).

2.2.17 Local Regulations
For the purposes of this document, local regulations include relevant local municipality, city, state, federal, national, or international requirements that must be followed at the particular location of use.

2.2.18 Mini-bulk
Mini-bulk containers are double walled, vacuum insulated containers (see Figure 2 below) available in a variety of sizes with capacities from approximately 150 to 750 pounds (70 to 350kg). Both inner and outer containers are usually stainless steel, although carbon steel is sometimes used. The inner container typically has a design pressure of 300 psig (20 bar) and an operating pressure of 125 psig (8.5 bar). Liquid CO₂ in mini-bulk containers is classified as refrigerated liquid (UN 2187).
2.2.19 PPB
Trace concentration level expressed as parts per billion.

2.2.20 PPM
Trace concentration level expressed as parts per million.

2.2.21 Reactivity Rating
The National Fire Protection Association (NFPA) rating for carbon dioxide is zero (0), which indicates that the material is normally stable, even under fire exposure conditions, and is not reactive with water. The rating is found in the right (yellow) box of the NFPA Diamond (U.S.).

2.2.22 Regulator
A mechanical device used in a gas delivery system to reduce the internal pressure of the system from a higher (source) pressure to a lower (delivery) pressure via an internal mechanism such as a diaphragm. Regulators may be made of many different types of materials (brass, stainless steel, etc.), and have varying designs (single-stage, two-stage, etc.) based upon their intended usage.

2.2.23 Relief Valve (also Pressure Relief Valve, Safety Relief Valve)
A safety device actuated by inlet static pressure and designed to open during an emergency or abnormal conditions to prevent a rise of internal fluid pressure in excess of a specified value.

2.2.23.1 The valve may be either a single-use type such as a rupture disc, or a re-usable (spring-loaded) type. If a single-use type relief valve is over pressurized, it will vent the entire contents of the source container, and will require replacement before the system can be put back into service.

2.2.23.2 A re-usable relief valve such as a spring-loaded device will vent excess pressure until an acceptable level is reached, at which point the valve will re-seat, allowing the system to function normally until another over-pressure condition occurs.

2.2.23.3 All relief valves should be properly sized and piped to vent outside the facility away from egress, structures, and personnel.
2.2.24 Residual Pressure Valve
A gas cylinder device that prevents a cylinder from being completely emptied, ensuring there is always a small amount of positive pressure kept in the cylinder.

2.2.24.1 This means that when an empty cylinder is stored outside awaiting collection, moisture cannot ingress from the atmosphere and contaminate the cylinder.

2.2.24.2 Without a residual pressure valve, empty cylinders could be left with the valve fully open and atmospheric contaminants could enter the cylinder, contaminating the contents when the cylinder is refilled.

2.2.24.3 Water and CO₂ can combine to form carbonic acid inside the cylinder, which can damage the metalwork over the life of the cylinder.

2.2.25 Specific Gravity
The ratio of the density of a substance to the density of water or air (no units). The specific gravity of carbon dioxide, 1.522, indicates that it is roughly one and a half times heavier than air, and will tend to settle in low-lying areas and enclosures.

2.2.26 Sublimation
The process of changing directly from the solid phase to the vapor phase, without passing through the liquid phase.

2.2.27 Triple point
The pressure and temperature at which a material exists simultaneously as a solid, liquid and vapor. For carbon dioxide the triple point is 60.4 psig (4.2 barg) and −70°F (−57°C).

2.2.28 Vapor Pressure
The pressure at which a liquid and its vapor are in equilibrium at a given temperature. Liquids with high vapor pressures evaporate rapidly. Liquid carbon dioxide will equilibrate inside a sealed container with a headspace pressure of approximately 838psig (57.7 barg) at 70ºF (21ºC).

3.0 General Carbon Dioxide Safety

**NOTE:** The information in this section should not be considered as a substitute for proper training of employees who must handle or be exposed to carbon dioxide. Refer to the carbon dioxide Material Safety Data Sheet (MSDS) provided by the carbon dioxide supplier for information regarding the associated hazards. Additional information on the properties and hazards of carbon dioxide can be found in the Compressed Gas Association publication G-6: Carbon Dioxide. Also refer to local regulations for requirements related to carbon dioxide and carbon dioxide storage systems.

3.1 General Hazards of Carbon Dioxide
3.1.1 Asphyxiation / Suffocation

3.1.1.1 Gaseous CO₂ can displace air and cause suffocation, and poses real dangers to personnel exposed to its various forms. CO₂ exists in the air and plays an important part in respiration. The act of breathing is actually driven by the need to eliminate CO₂ rather than the need for oxygen. As a result, increasing the CO₂ content of the air will affect respiration and can cause suffocation even when there would still seem to be adequate oxygen to support life. Therefore, the tolerance levels for CO₂ can be less than for other asphyxiant gases.

3.1.1.2 Ambient air contains CO₂ at a level of approximately 350 ppm (0.035%) by volume. The U.S. Occupational Safety and Health Administration (OSHA) has established worker exposure limits to airborne concentrations of CO₂ at the levels shown in the Appendix. Local regulations should be consulted for CO₂ exposure limits, where applicable.

See Appendix 8.1 – OSHA Exposure Classification
See Appendix 8.2 - Symptoms of CO₂ Exposure

3.1.1.3 Carbon dioxide gas is 1.5 times heavier than air and if spilled or released, will collect near the floor and accumulate in low areas such as trenches, pits and sumps. Do not enter an area suspected of having a high concentration of carbon dioxide without testing the atmosphere or using a supplementary breathing air supply. Areas where carbon dioxide is stored and used must be well ventilated, with extraction and makeup air at proper elevations to prevent accumulation of carbon dioxide gas.

See Appendix 8.4 - CO₂ Pressure and Temperature Data

3.1.2 Corrosion

3.1.2.1 Small leaks of CO₂ can react with atmospheric moisture to form carbonic acid (a weak acid) which may corrode carbon steel piping or equipment.

3.1.3 Special Hazards

3.1.3.1 Do not allow liquid CO₂ to become trapped between closed valves. As the liquid CO₂ warms, it expands and the pressure rises dramatically. This increase can easily exceed the pressure rating of the pipe or hose, causing it to rupture, with the potential for injury and/or property damage. Pressure relief valves must be
installed on all lines where liquid \( \text{CO}_2 \) could become trapped between valves.

3.1.3.2 Ball valves used for liquid \( \text{CO}_2 \) service must be specially designed to include the capability to relieve pressure resulting from liquid \( \text{CO}_2 \) being trapped in the ball cavity (typically self-relieving seats or a pressure relief hole drilled in the upstream side of the ball).

3.1.3.3 When the pressure on liquid \( \text{CO}_2 \) is released, it forms a mixture of gas and solid. Dry ice (solid \( \text{CO}_2 \)) plugs can be formed inside liquid \( \text{CO}_2 \) hoses and piping when the pressure is decreased below the \textit{triple point} pressure of 60.4 psig (4.2 bar). The dry ice can be compacted into a plug that can trap gas. The pressure behind a plug may increase as the dry ice \textit{sublimes} until the plug is forcibly ejected or the hose or pipe ruptures, possibly causing injury or property damage.

3.1.3.4 Liquid carbon dioxide must be purged from the hose or pipe before reducing the pressure below 75 psig (5.2 bar). This can be done by supplying carbon dioxide vapor to one end of the hose or piping system to maintain the pressure above the \textit{triple point} while removing the remaining liquid from the other end. Only properly trained personnel should attempt to depressurize liquid carbon dioxide piping or hoses.

3.2 Emergency Response

\textbf{NOTE:} In all cases of carbon dioxide exposure, inhalation or physical contact, the affected individual should seek immediate medical attention.

3.2.1 If someone has been exposed to high concentrations of \( \text{CO}_2 \), or has suffered frost burns from \( \text{CO}_2 \) vapor or dry ice, immediately notify emergency personnel (e.g. fire department, emergency medical services).

3.2.2 \( \text{CO}_2 \) inhalation

3.2.2.1 Do not attempt to remove anyone who has been exposed to high \( \text{CO}_2 \) concentrations, unless you have been trained in the use of and are wearing appropriate self-contained or air-supplied breathing apparatus. Do not enter an area that is suspected to have high \( \text{CO}_2 \) levels unless an area or personal \( \text{CO}_2 \) specific monitor reading confirms the area is safe to enter. Wait for emergency personnel to respond. \textbf{NOTE:} Canister or chemical cartridge respirators provide no protection in atmospheres containing dangerous concentrations of \( \text{CO}_2 \).
3.2.2.2 Only if you can do so at no risk to yourself, remove the affected person to fresh air. If the person is not breathing, perform artificial respiration, if you have been trained to do so. If breathing is difficult, only qualified personnel should administer oxygen. Keep the affected person warm and at rest.

3.2.3 CO₂ contact

3.2.3.1 In the case of eye contact, immediately flush the eyes with plenty of water for at least 15 minutes.

3.2.3.2 In the case of skin contact, immediately flush the affected skin with water. Remove any contaminated clothing and shoes and thoroughly cleanse before reuse.

3.2.3.3 In the case of frost burn, carefully warm the frozen tissues by immersion in lukewarm water. Do not rub the affected area.

3.3 Piping Systems

3.3.1 Carbon dioxide piping systems shall be of suitable materials, such as stainless steel, copper and brass, and shall be installed in accordance with appropriate local regulations (e.g. ANSI B31.3, Process Piping).

3.3.2 Any flexible hose and fittings used as components of the piping system must have a pressure rating appropriate for the design pressure of the system (burst pressure at least four times the system design pressure). Hoses should be of materials suitable for gaseous or liquid CO₂ service that do not release substances such as plasticizers or other contaminants into the gaseous or liquid CO₂ stream.

3.3.3 All connections shall be pressure tight and leak tested to confirm that they are leak free (leak detection fluid must be compatible with CO₂).

3.3.4 Mini-bulk system fill connections shall be located outdoors.

3.3.5 Relief valves and vent piping from mini-bulk containers should be vented outside away from egress, structures and personnel.

3.3.6 Care should be taken to protect the CO₂ supply system from accidental damage or tampering, including the fill box, piping to the mini-bulk container, and vent piping.
3.4 Handling and Storage of Cylinders and Mini-Bulk Containers

3.4.1 Best practice for personnel handling cylinders or connecting or disconnecting hoses to or from cylinders is to wear a long sleeved shirt, long legged pants (trousers), loose leather gloves, safety shoes, and safety glasses meeting regulatory requirements (e.g. ANSI standard Z87.1).

3.4.2 In addition to the items listed in 3.4.1, best practice for personnel handling mini-bulk containers or connecting or disconnecting hoses to or from mini-bulk containers is to wear a face shield meeting regulatory requirements (e.g. ANSI standard Z87.1).

3.4.3 Before disconnecting cylinders or mini-bulk containers from the CO₂ supply system, close the cylinder or container valve to prevent the escape of residual CO₂. Failure to close the valve fully may result in ambient air contamination entering the empty container.

3.4.4 A properly designed cylinder cart should be used to move cylinders.

3.4.5 Cylinders and mini-bulk containers should be stored and used upright.

3.4.6 Cylinders and mini-bulk containers shall be secured to prevent them from falling or being knocked over. Portable cylinders and mini-bulk containers may be secured by use of a strap, chain or restraining device. Stationary mini-bulk containers shall be restrained to the floor or structure.

3.4.7 Do not locate cylinders or mini-bulk containers near elevators or where they can fall from ledges, platforms or stairwells.

3.4.8 Cylinders and mini-bulk containers should be protected from the possibility of falling objects.

3.4.9 Do not place anything on top of cylinders or mini-bulk containers – they are not to be used as shelves.

3.4.10 Locate cylinders and mini-bulk containers away from open flames and high temperature devices. Cylinders should not be stored in direct sunlight, if possible or exposed to temperatures exceeding 125°F (52°C).

3.4.11 Do not locate cylinders or mini-bulk containers where they can become part of an electrical circuit.
3.4.12 A warning sign containing language equivalent to the illustration below should be posted at the service entrance to confined spaces where cylinders or mini-bulk containers are stored or used.

CAUTION – CARBON DIOXIDE GAS

Ventilate the area before entering.

A high carbon dioxide (CO₂) gas concentration may occur in this area and may cause suffocation.

3.4.13 Enclosed areas where cylinders or mini-bulk containers are stored or used should be equipped with a CO₂ monitoring system and adequate ventilation (see section 3.5, below).

3.5 Gas Detection and Ventilation Equipment

3.5.1 A safety assessment should be performed to determine the appropriate level of protection, especially when cylinders or mini-bulk containers are stored indoors. This is extremely important when the installation is below ground level or in a confined space (see note below). Potential risk mitigation might include gas detection or ventilation equipment should the assessment deem them necessary. See Section 3.1.1 for more information on the asphyxiation and suffocation hazards of carbon dioxide. Refer to local regulations for requirements related to gas detection and ventilation.

NOTE: Because carbon dioxide gas is 1.5 times heavier than air, CO₂ released (for example, from a leaking valve) tends to fill an area much like water would. Therefore, confined spaces can include walled outdoor areas without roofs, but with closed doors.

3.5.2 It is recommended that the CO₂ gas detector(s) be installed at a height of about 3 to 4 ft (1 to 1.25 m) above floor level. However, you should work with your CO₂ supplier and the CO₂ detector manufacturer to determine the best location for the detector(s).

3.5.3 Do not rely on measurement of the oxygen content of the air since a dangerous level of carbon dioxide may be present, even though the oxygen level is adequate for life support.

3.5.4 The gas detection system should provide an audible and visible alarm to notify occupants when the CO₂ reaches a dangerous level (0.5% as an
example). The gas detection system should be equipped with a standby power supply (in accordance with NFPA 111, “Stored Electrical Energy Emergency and Standby Power Systems”).

3.5.5 Ventilation (mechanical, natural, or a combination thereof) should be installed that provides makeup air at a flow rate of 1.0 cfm per square foot (300 l/min per square meter) of floor area in a confined space. Since CO₂ will tend to accumulate at floor level, the ventilation system should be designed to exhaust from the lowest elevation in the confined space and to introduce makeup air at a higher elevation.

See Appendix 8.3 Properties of Carbon Dioxide
4.0 Fountain Beverage Quality Carbon Dioxide

4.1 Fountain CO₂ Purity Guideline

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Guideline</th>
<th>Rationale¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purity:</td>
<td>99.9 % v/v min.</td>
<td>Process</td>
</tr>
<tr>
<td>Moisture:</td>
<td>20 ppm v/v max.</td>
<td>Process</td>
</tr>
<tr>
<td>Oxygen:</td>
<td>30 ppm v/v max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>Carbon Monoxide:</td>
<td>10 ppm v/v max.</td>
<td>Process</td>
</tr>
<tr>
<td>Ammonia:</td>
<td>2.5 ppm v/v max.</td>
<td>Process</td>
</tr>
<tr>
<td>Nitric Oxide / Nitrogen Dioxide:</td>
<td>2.5 ppm v/v max. (each)</td>
<td>Regulatory</td>
</tr>
<tr>
<td>Non-volatile Residue:</td>
<td>10 ppm w/w max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>Non-volatile Organic Residue:</td>
<td>5 ppm w/w max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>Phosphine:</td>
<td>To pass test (0.3 ppm v/v max.)</td>
<td>Regulatory</td>
</tr>
<tr>
<td>Total Volatile Hydrocarbons:</td>
<td>50 ppm v/v max. including 20 ppm v/v max. as total non-methane hydrocarbons</td>
<td>Sensory</td>
</tr>
<tr>
<td>Acetaldehyde:</td>
<td>0.2 ppm v/v max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>Aromatic Hydrocarbon Content:</td>
<td>20 ppb v/v max.</td>
<td>Regulatory</td>
</tr>
<tr>
<td>Total Sulfur Content* (as S):</td>
<td>0.1 ppm v/v max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>Sulfur Dioxide:</td>
<td>1 ppm v/v max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>Odor of Solid CO₂ (Snow):</td>
<td>No foreign odor</td>
<td>Sensory</td>
</tr>
<tr>
<td>Appearance in Water:</td>
<td>No color or turbidity</td>
<td>Sensory</td>
</tr>
<tr>
<td>Odor &amp; Taste in Water:</td>
<td>No foreign odor or taste</td>
<td>Sensory</td>
</tr>
</tbody>
</table>

¹ Rationale definitions:
- Sensory: Any attribute that negatively impacts the taste, appearance, or odor of beverage.
- Process: Any attribute that defines a key parameter in a controlled process and an important consideration in the beverage industry.
- Regulatory: Any attribute whose limit is set by governing regulatory agencies.
4.2 Potential Sources of Impurities and Contaminants

The CO₂ supply chain for fountain CO₂ is indicated in Figure 3. In order to maintain the product quality and integrity the CO₂ supplier shall have in place an effective quality management system based on the principles of ISO (International Standards Organization) 9000. The CO₂ supply chain is quite complex with a number of opportunities for the ingress of contamination and particular care is required at each stage of handling. The table below identifies particular sources of contamination derived from experience. This list is not exhaustive, and the CO₂ supplier is encouraged to apply the principles of HACCP to identify risks in the individual supply chain.
<table>
<thead>
<tr>
<th><strong>Contaminant Type</strong></th>
<th><strong>Point in Supply Chain</strong></th>
<th><strong>Contaminant Source</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallic oxides and other fine particulate matter</td>
<td>Depot storage tank, Bulk supply tank trucks, Mini-bulk tanks, Gas cylinders</td>
<td>Container corrosion / filter bed fines / transfer hose wear</td>
</tr>
<tr>
<td>Various chemical impurities possible</td>
<td>Shipments of bulk CO₂, Depot tank storage, Mini-bulk or bulk tanks</td>
<td>Cross-contamination from the supply-chain or outlet’s process</td>
</tr>
<tr>
<td>Plasticizers</td>
<td>Hose transfer of liquid CO₂ into mini-bulk or bulk tanks, Gas cylinder filling fountain facility tubing</td>
<td>Leaching of plasticizing agents from improper or aged flexible hoses due to the strong solvent effects of liquid CO₂ / poor facility tubing maintenance</td>
</tr>
<tr>
<td>Air (oxygen, nitrogen) / water vapor</td>
<td>All CO₂ transfer steps or point-of-use outlet gas transfers</td>
<td>Atmospheric air ingress into transfer hoses / valves</td>
</tr>
<tr>
<td>Non-or semi-volatile impurities such as oils, water, aromatic hydrocarbons</td>
<td>Depot storage tanks, Mini-bulk tanks, Gas cylinders</td>
<td>Potential concentration of trace non-volatile or semi-volatile impurities as vapor is withdrawn from a liquid CO₂ storage vessel</td>
</tr>
<tr>
<td>Various atmospheric gases, vapors, particulates, bio-agents</td>
<td>Empty Gas cylinders</td>
<td>Aspiration of ambient air into empty gas cylinders if stored with open valves</td>
</tr>
</tbody>
</table>

Figure 4 – Potential CO₂ Supply Chain Contamination Sources

5.0 CO₂ Production Source – Supply Chain Vendor Certification Guidelines

5.1 CO₂ Product Sourcing

All liquid CO₂ used for fountain beverage production should comply with ISBT CO₂ Quality Guidelines (see 4.1 above). The CO₂ production facility should demonstrate through analysis that their liquid CO₂ product is ISBT beverage grade (the recommended analytical certification point is identified in Figure 3 above).

A Certificate of Analysis / Compliance from a supply chain vendor demonstrates ISBT beverage grade quality CO₂ has been sourced and provides traceability back to the CO₂ production facility. Supply chain vendors should have this source certification on file for all deliveries of CO₂, and should be capable of producing this document for a fountain customer when requested.

5.2 CO₂ Product Handling / Storage / Transfer / Security

The supply chain vendor should have documented operational procedures that ensure total CO₂ transfer integrity from the producer site to fountain facility. These procedures should include: receiving, storing, handling, filling, and delivery. The supply chain vendor should also have a documented security plan to protect CO₂ quality from tampering during all intermediate transport and storage stages.

5.3 CO₂ Supply Chain Traceability and Recall

The supply chain vendor should have a documented procedure that ensures the traceability of a delivered fountain CO₂ load back through the entire supply chain.
system to the producer source. A documented procedure should also be in place that ensures an effective CO$_2$ product recall can occur if needed.

See Appendix 8.6 CO$_2$ Vendor Checklist

6.0 Fountain Equipment Systems

6.1 Maintenance

All equipment that could come into contact with the CO$_2$ should be suitable for the application and designed to preclude ingress of any potential CO$_2$ contamination. Steps should be taken during all installation, operation, and maintenance periods to avoid unsafe conditions and operator exposure to CO$_2$.

Only a competent, qualified person familiar with all applicable safety requirements should carry out any installation and maintenance procedures.

A maintenance program should be in place to allow for preventative, predictive and corrective maintenance of key dispense equipment.

To ensure optimum system performance all maintenance procedures should be carried out in accordance with the equipment manufacturer’s recommendations.

Items requiring regular cleaning, inspection, and/or maintenance include:

- Primary and Secondary Regulators
- In-line CO$_2$ Filter/Polisher - optional
- Carbonator
- Syrup Pumps
- Tubing and Fittings

6.2 Description of Fountain Equipment

This information is intended as a guide for customer installations; final approval of the design, equipment, and installation should be based on local regulations. Additional information is published in CGA G-6.5 “Standard for Small, Stationary, Insulated Carbon Dioxide Supply Systems.”
All items used in the handling and distribution of carbon dioxide must be constructed using suitable materials, with relevant FDA (or applicable local regulatory authority) compliance and should not release any contaminants that could have an impact on the carbon dioxide or final beverage quality.

1 **Gas Storage Vessel**

CO₂ is typically stored in *mini-bulk* containers or *compressed gas cylinders* (see Section 2.2 Definition of Terms for detailed descriptions).

2 **Pressure Regulator**

Immediately after the gas storage vessel [1], whether it be a gas cylinder or mini-bulk-tank, there must be a pressure regulator [2] to reduce the storage pressure to the system pressure (to feed the carbonator [7] or syrup pumps [11]). The system pressure should be adjusted to the required value by a qualified beverage dispense technician or by your gas supplier.

3 **Pressure Gauges**

The first pressure gauge displays the pressure in the CO₂ storage vessel. The second gauge displays the line pressure downstream of the pressure regulator [2].

4 **Tubing and Fittings**

Any rigid or flexible tubing, fittings, and hoses used as part of the gas pipeline must be suitable for the application with regard to pressure rating and materials compatibility.

Note – See Tables 2,3 and 4 in CGA G-6.1 (Section 6) or IGC 66/99: “Refrigerated CO₂ Storage at Users' Premises,” for further information on materials of construction.

5 **In-line CO₂ Filter/Polisher** (Optional)
Where appropriate for the application and recommended by your supplier, an in-line CO₂ filter/polisher [5] may be installed.

6 Check Valve


7 Carbonator

CO₂ passes though a check valve [6], which prevents water from backing up into the CO₂ supply, and fills the carbonator tank with CO₂. The incoming filtered water either proceeds through a cooling coil in a water bath or directly (for ambient carbonators) into the carbonator tank. The pressurized CO₂ is absorbed into the water, which then flows to the dispenser. All equipment supplier-recommended pressures must be maintained for proper operation.

8 Water Supply

Water supply should be from a potable source (municipality or well). Well water must be tested as potable by a recognized testing laboratory.

9 Water Filter (Optional)

Water flows through the filter to remove particles and taste/odor causing chemicals that are contained in the water supply. This allows for a consistent, clean taste in the beverages. All equipment supplier-recommended pressures must be maintained for proper operation.

10 Bag in Box (BIB) Syrup

A delivery system for fountain syrup, consisting of a sealed, collapsible bag, inside a rigid outer container. It is normally shipped ready-to-use by the beverage manufacturer and should be protected from tampering at all times.

11 Syrup Pumps

Powered by either air or CO₂ and used to pump syrup from the BIB storage to the fountain.

12 Fountain Dispenser

The incoming carbonated water and syrup passes through cooling coils, located in a water bath or cast into an aluminum cold-plate, to chill the beverage components to the desired serving temperature.

13 Post-Mix Dispensing Valves

Post-mix dispensing valves are typically installed on the dispenser or tower. The carbonated water and syrup is blended at a predetermined ratio and flowrate at the valve.

Post-mix dispensing valves typically include an actuator (such as a lever or push-button), a nozzle and a diffuser assembly. The nozzle and diffuser assembly functions to thoroughly mix carbonated water with syrup, while minimizing the amount of foaming and carbonation breakout. Beverage blending occurs as the syrup and water enters the nozzle of the valve. Blending will continue as the beverage is captured in the cup.
The valve nozzle should be cleaned on a daily basis to deter contamination and ensure proper flow.

Modern post-mix dispensing valves are equipped with adjustable flow controls that react to line pressure changes and open / close orifices to keep a constant ratio of water to syrup.
7.0 References

7.1 Carbon Dioxide Quality Guidelines and Analytical Procedure Bibliography, International Society of Beverage Technologists (ISBT), U.S.

7.2 Commodity Specification For Carbon Dioxide, CGA G-6.2, Compressed Gas Association (CGA), U.S.


7.4 Carbon Dioxide Source Certification, Quality Standards and Verification, IGC Document 70/99/E, European Industrial Gases Association, EIGA, Belgium.

7.5 OSHA Standard –29 CFR 1910.146(b), U.S.

7.6 CGA G-6.3, section 2.7, Compressed Gas Association (CGA), U.S.


7.8 Transportation of Dangerous Goods Regulations Canadian Communications Publishing, Ordering Department, Ottowa, ON, Canada K1A 0S9.

8.0 Appendix

8.1 OSHA Exposure Classification

<table>
<thead>
<tr>
<th>OSHA Exposure Classification</th>
<th>Limit in Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEL – Permissible Exposure Limit (during 8 hours)</td>
<td>5,000 ppm</td>
</tr>
<tr>
<td>STEL – Short Term Exposure Limit (during 15 minutes)</td>
<td>30,000 ppm</td>
</tr>
<tr>
<td>IDLH – Immediately Dangerous to Life and Health</td>
<td>40,000 ppm</td>
</tr>
</tbody>
</table>
8.2 Symptoms of CO₂ Exposure

<table>
<thead>
<tr>
<th>CO₂ Concentration (by volume)</th>
<th>Symptom – Likely Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1.5%</td>
<td>Slight effect on chemical metabolism after exposures of several hours.</td>
</tr>
<tr>
<td>3%</td>
<td>The gas is weakly narcotic at this level, giving rise to deeper breathing, reduced hearing ability, coupled with headache, an increase in blood pressure and pulse rate.</td>
</tr>
<tr>
<td>4-5%</td>
<td>Stimulation of the respiratory center occurs resulting in deeper and more rapid breathing. Signs of intoxication will become evident after 30 minutes of exposure.</td>
</tr>
<tr>
<td>5-10%</td>
<td>Breathing becomes more laborious with headache and loss of judgment.</td>
</tr>
<tr>
<td>10-100%</td>
<td>When carbon dioxide concentration increases above 10%, unconsciousness will occur in less than one minute and unless prompt action is taken, further exposure to these high levels will eventually result in death.</td>
</tr>
</tbody>
</table>

8.3 Properties of Carbon Dioxide

8.3.1 Carbon dioxide is a colorless, odorless, slightly acidic, nonflammable gas that is 1.5 times heavier than air. It can be liquefied to a heavy, volatile, colorless liquid. The main properties of CO₂ are summarized in the table below.

8.3.2 Table of CO₂ Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular Formula</td>
<td>CO₂</td>
</tr>
<tr>
<td>Molecular weight</td>
<td>44.01</td>
</tr>
<tr>
<td>Vapor pressure (uninsulated cylinder)</td>
<td>838 psig at 70°F (57.7 bar at 21°C)</td>
</tr>
<tr>
<td>Vapor pressure (insulated mini-bulk container)</td>
<td>125 psig at –42°F (8.6 bar at –41°C)</td>
</tr>
<tr>
<td>Boiling (Sublimation) Point at atmospheric pressure</td>
<td>–109°F (–78.5°C)</td>
</tr>
<tr>
<td>Specific gravity (gaseous)</td>
<td>1.52</td>
</tr>
<tr>
<td>Physical State at 70°F (21°C) and atmospheric pressure</td>
<td>Gas</td>
</tr>
<tr>
<td>Flammability</td>
<td>Nonflammable</td>
</tr>
</tbody>
</table>
8.4 CO₂ Pressure and Temperature Data

8.4.1 Personnel should be aware of the dangers of potentially high pressures and low temperatures when working with CO₂.

8.4.2 CO₂ in cylinders (Compressed gas – UN 1013) is typically at ambient temperature. The pressure in a CO₂ cylinder can range from 638 psig (44 bar) at an ambient temperature of 50°F (10°C) to 955 psig (66 bar) at an ambient temperature of 80°F (27°C).

8.4.3 Liquid CO₂ stored in mini-bulk containers (Refrigerated Liquid – UN 2187) is typically at a pressure of about 125 psig (8.6 bar), but the pressure can be as high as 300 (20.7 bar) psig. Under these pressures, the liquid CO₂ temperature will range from −42°F to +2°F (−41°C to −17°C).

8.4.4 When CO₂ in a cylinder or mini-bulk container is released to atmospheric pressure, the liquid CO₂ will rapidly boil to form a mixture of gaseous and solid (dry ice) CO₂ at −109°F (−78°C). Contact with liquid CO₂ or the cold gas or solid can cause exposed tissues to freeze.
8.5 *Fountain CO₂* Purity Guideline

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Guideline</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purity:</td>
<td>99.9 % v/v min.</td>
<td>Process</td>
</tr>
<tr>
<td>Moisture:</td>
<td>20 ppm v/v max.</td>
<td>Process</td>
</tr>
<tr>
<td>Oxygen:</td>
<td>30 ppm v/v max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>Carbon Monoxide:</td>
<td>10 ppm v/v max.</td>
<td>Process</td>
</tr>
<tr>
<td>Ammonia:</td>
<td>2.5 ppm v/v max.</td>
<td>Process</td>
</tr>
<tr>
<td>Nitric Oxide / Nitrogen Dioxide:</td>
<td>2.5 ppm v/v max. (each)</td>
<td>Regulatory</td>
</tr>
<tr>
<td>Non-volatile Residue:</td>
<td>10 ppm w/w max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>Non-volatile Organic Residue:</td>
<td>5 ppm w/w max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>Phosphine:</td>
<td>To pass test (0.3 ppm v/v max.)</td>
<td>Regulatory</td>
</tr>
<tr>
<td>Total Volatile Hydrocarbons:</td>
<td>50 ppm v/v max. including 20 ppm v/v max. as total non-methane hydrocarbons</td>
<td>Sensory</td>
</tr>
<tr>
<td>Acetaldehyde:</td>
<td>0.2 ppm v/v max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>Aromatic Hydrocarbon Content:</td>
<td>20 ppb v/v max.</td>
<td>Regulatory</td>
</tr>
<tr>
<td>Total Sulfur Content* (as S):</td>
<td>0.1 ppm v/v max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>(*Total sulfur-containing impurities excluding sulfur dioxide)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur Dioxide:</td>
<td>1 ppm v/v max.</td>
<td>Sensory</td>
</tr>
<tr>
<td>Odor of Solid CO₂ (Snow):</td>
<td>No foreign odor</td>
<td>Sensory</td>
</tr>
<tr>
<td>Appearance in Water:</td>
<td>No color or turbidity</td>
<td>Sensory</td>
</tr>
<tr>
<td>Odor &amp; Taste in Water:</td>
<td>No foreign odor or taste</td>
<td>Sensory</td>
</tr>
</tbody>
</table>

¹ Rationale definitions:

Sensory: Any attribute that negatively impacts the taste, appearance, or odor of beverage.

Process: Any attribute that defines a key parameter in a controlled process and an important consideration in the beverage industry

Regulatory: Any attribute whose limit is set by governing regulatory agencies
8.6 CO₂ Vendor Checklist

This is an example of some recommended questions that could be used to qualify a prospective fountain CO₂ vendor.

**CO₂ Vendor Checklist**

1. **Product Quality**
   - Is the vendor supplying *beverage grade* product?
   - Is the product supplied in compliance with the guidelines in this document?
   - Are Certificates of Compliance / Analysis available on request?

2. **Traceability**
   - Can the supplier provide documentation, on request, that will provide for traceability of the delivered load to the point of manufacture?

3. **CO₂ Storage Equipment**
   - Does the proposed design meet *ISBT* minimum requirements?
   - Do all equipment components meet *ISBT* standards?
   - Are all materials certified to be CO₂ compatible?
   - Does the equipment comply with minimum *local regulations*?

4. **Security**
   - Where applicable, are remote fill boxes secured?
   - Is CO₂ storage equipment protected from tampering? (*gas cylinders* and *mini-bulk* containers)