INTERNATIONAL SOCIETY of BEVERAGE TECHNOLOGISTS

Fountain Carbon Dioxide Quality Guideline

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Contents

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1.0 Introduction

This quality guideline focuses on purity grade selection, transport, storage, dispensing and safe handling of carbon dioxide (CO_2) used in *fountain* beverage production. An expert international committee comprised of beverage manufacturers, CO_2 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 CO_2 supply chain vendors.

The function of dissolved CO_2 gas in beverages is to provide effervescence and some acidity without introducing any undesired sensory effects. As CO_2 is a key ingredient in many *fountain* products, CO_2 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 CO_2 at outlet sites.

Beverage grade CO_2, 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 CO_2 to *fountain* facilities, additional *contaminants* may be introduced into a *beverage grade* CO_2 delivery by improper transport, storage or outlet dispensing practices. It is the responsibility of a CO_2 producer to identify, measure and control all listed *impurities* at acceptable levels in their final CO_2 product. *Fountain* CO_2 customers are responsible for ensuring that all of their CO_2 supply chain vendors follow good manufacturing and handling practices and have met their obligation to provide *beverage grade* CO_2 to their facilities. In addition, *fountain* operators should also recognize that poorly designed or maintained fountain hardware can degrade CO_2 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* CO_2 quality guideline limits are readily measurable and achievable. Supply chain vendor protocol recommendations are offered to *fountain* operators regarding CO_2 quality traceability.

This document also includes useful information about common carbonation systems, operational and maintenance practices involving CO_2 *mini-bulk* tanks and *gas cylinders* along with a review of safe CO_2 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 $\mathbf{CO_2}$
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

Transport Canada

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 CO_2 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 70ºF (21ºC), or over 89 psig at 130ºF (54ºC), or over 25 psig at 100ºF (38ºC) 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 CO_2 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]."

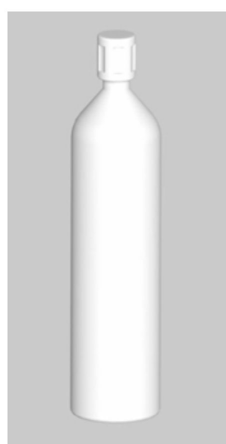

Figure 1 – *Gas Cylinder*

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 CO_2, coming from either the initial feed gas source or from the manufacturing process. Processing and purification of the feed gas CO_2 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 CO_2 Filter/Polisher

An *in-line CO_2 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 CO_2 filters/polishers act as a final multi-layer barrier against trace *impurities* in a CO_2 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 CO_2 in *mini-bulk* containers is classified as refrigerated liquid (UN 2187).

Figure 2 – *Mini-bulk* Tank

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 *cylinder*s 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 CO_2 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 pressure*s 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 *CO_2* can displace air and cause suffocation, and poses real dangers to personnel exposed to its various forms. *CO_2* exists in the air and plays an important part in respiration. The act of breathing is actually driven by the need to eliminate *CO_2* rather than the need for oxygen. As a result, increasing the *CO_2* 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 *CO_2* can be less than for other *asphyxiant* gases.

3.1.1.2 Ambient air contains *CO_2* 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 *CO_2* at the levels shown in the Appendix. Local regulations should be consulted for *CO_2* exposure limits, where applicable.

See Appendix 8.1 – *OSHA* Exposure Classification
See Appendix 8.2 - Symptoms of *CO_2* 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 - *CO_2* Pressure and Temperature Data

3.1.2 Corrosion

3.1.2.1 Small leaks of *CO_2* 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 *CO_2* to become trapped between closed valves. As the liquid *CO_2* 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 CO_2 could become trapped between valves.

3.1.3.2 Ball valves used for liquid CO_2 service must be specially designed to include the capability to relieve pressure resulting from liquid 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 CO_2 is released, it forms a mixture of gas and solid. Dry ice (solid CO_2) plugs can be formed inside liquid CO_2 hoses and piping when the pressure is decreased below the *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 *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 *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

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 CO_2, or has suffered frost burns from CO_2 vapor or dry ice, immediately notify emergency personnel (e.g. fire department, emergency medical services).

3.2.2 CO_2 inhalation

3.2.2.1 Do not attempt to remove anyone who has been exposed to high 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 CO_2 levels unless an area or personal CO_2 specific monitor reading confirms the area is safe to enter. Wait for emergency personnel to respond. **NOTE:** Canister or chemical cartridge respirators provide no protection in atmospheres containing dangerous concentrations of 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 CO_2 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 CO_2 service that do not release substances such as plasticizers or other *contaminants* into the gaseous or liquid CO_2 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 CO_2).

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 CO_2 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 *Cylinder*s and *Mini-Bulk* Containers

3.4.1 Best practice for personnel handling *cylinder*s or connecting or disconnecting hoses to or from *cylinder*s 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 CO_2 supply system, close the *cylinder* or container valve to prevent the escape of residual CO_2**.** 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 (CO_2) 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 CO_2 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, CO_2 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 CO_2 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 CO_2 supplier and the CO_2 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 CO_2 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 CO_2 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* CO_2 Purity Guideline

Parameter	Guideline	Rationale[1]
Purity:	99.9 % v/v min.	Process
Moisture:	20 *ppm* v/v max.	Process
Oxygen:	30 *ppm* v/v max.	Sensory
Carbon Monoxide:	10 *ppm* v/v max.	Process
Ammonia:	2.5 *ppm* v/v max.	Process
Nitric Oxide / Nitrogen Dioxide:	2.5 *ppm* v/v max. (each)	Regulatory
Non-volatile Residue:	10 *ppm* w/w max.	Sensory
Non-volatile Organic Residue:	5 *ppm* w/w max.	Sensory
Phosphine:	To pass test (0.3 *ppm* v/v max.)	Regulatory
Total Volatile Hydrocarbons: (as Methane)	50 *ppm* v/v max. including 20 *ppm* v/v max. as total non-methane hydrocarbons	Sensory
Acetaldehyde:	0.2 *ppm* v/v max.	Sensory
Aromatic Hydrocarbon Content:	20 *ppb* v/v max.	Regulatory
Total Sulfur Content* (as S): (*Total sulfur-containing *impurities* excluding sulfur dioxide)	0.1 *ppm* v/v max.	Sensory
Sulfur Dioxide:	1 *ppm* v/v max.	Sensory
Odor of Solid CO_2 (Snow):	No foreign odor	Sensory
Appearance in Water:	No color or turbidity	Sensory
Odor & Taste in Water:	No foreign odor or taste	Sensory

[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*

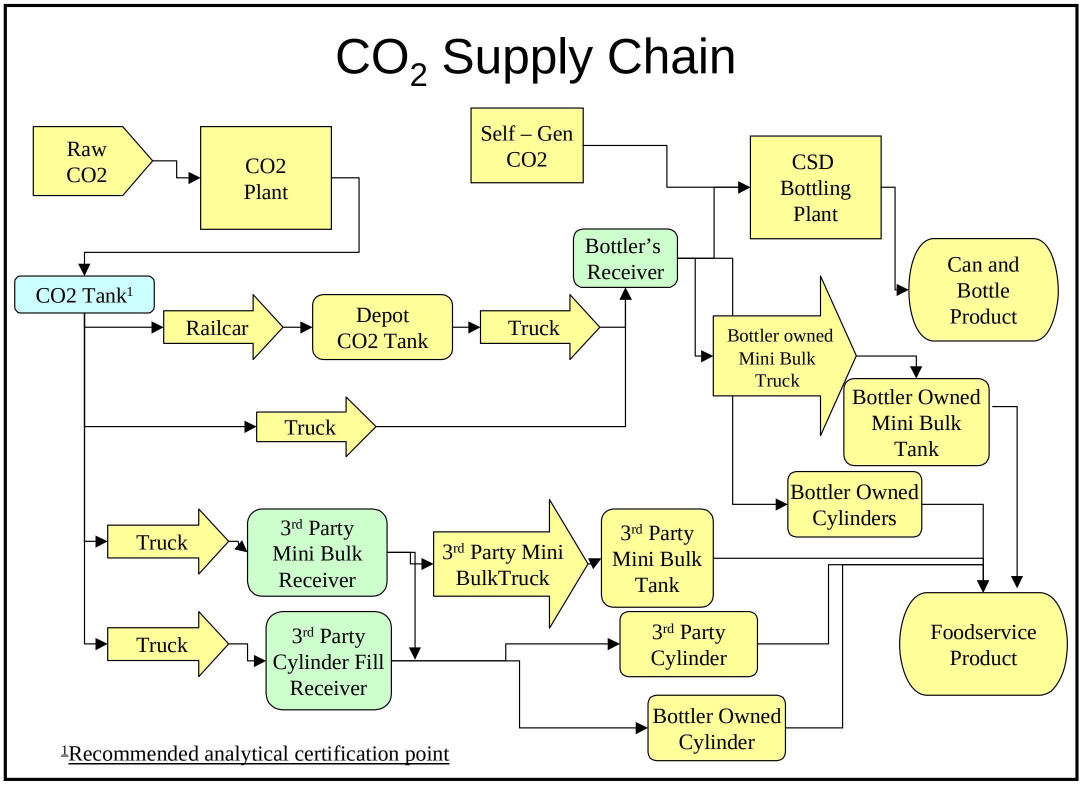

Figure 3 – CO_2 Supply Chain

The CO_2 supply chain for *fountain* CO_2 is indicated in Figure 3. In order to maintain the product quality and integrity the CO_2 supplier shall have in place an effective quality management system based on the principles of ISO (International Standards Organization) 9000. The CO_2 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 CO_2 supplier is encouraged to apply the principles of *HACCP* to identify risks in the individual supply chain.

***Contaminant* Type**	**Point in Supply Chain**	***Contaminant* Source**
Metallic oxides and other fine particulate matter	Depot storage tank Bulk supply tank trucks *Mini-bulk* tanks *Gas cylinders*	Container corrosion / filter bed fines / transfer hose wear
Various chemical *impurities* possible	Shipments of bulk CO_2 Depot tank storage *Mini-bulk* or bulk tanks	Cross-*contamination* from the supply-chain or outlet's process
Plasticizers	Hose transfer of liquid CO_2 into *mini-bulk* or bulk tanks, *Gas cylinder* filling *fountain* facility tubing	Leaching of plasticizing agents from improper or aged flexible hoses due to the strong solvent effects of liquid CO_2 / poor facility tubing maintenance
Air (oxygen, nitrogen) / water vapor	All CO_2 transfer steps or point-of-use outlet gas transfers	Atmospheric air ingress into transfer hoses / valves
Non-or semi-volatile *impurities* such as oils, water, aromatic hydrocarbons	Depot storage tanks *Mini-bulk* tanks *Gas cylinders*	Potential concentration of trace non-volatile or semi-volatile *impurities* as vapor is withdrawn from a liquid CO_2 storage vessel
Various atmospheric gases, vapors, particulates, bio-agents	Empty *Gas cylinders*	Aspiration of ambient air into empty *gas cylinders* if stored with open valves

Figure 4 – Potential CO_2 Supply Chain *Contamination* Sources

5.0 CO_2 Production Source – Supply Chain Vendor Certification Guidelines

5.1 CO_2 Product Sourcing

All liquid CO_2 used for *fountain* beverage production should comply with *ISBT CO_2* Quality Guidelines (see 4.1 above). The CO_2 production facility should demonstrate through analysis that their liquid CO_2 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 CO_2 has been sourced and provides traceability back to the CO_2 production facility. Supply chain vendors should have this source certification on file for all deliveries of CO_2, and should be capable of producing this document for a *fountain* customer when requested.

5.2 CO_2 Product Handling / Storage / Transfer / Security

The supply chain vendor should have documented operational procedures that ensure total CO_2 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 CO_2 quality from tampering during all intermediate transport and storage stages.

5.3 CO_2 Supply Chain Traceability and Recall

The supply chain vendor should have a documented procedure that ensures the traceability of a delivered *fountain* CO_2 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."

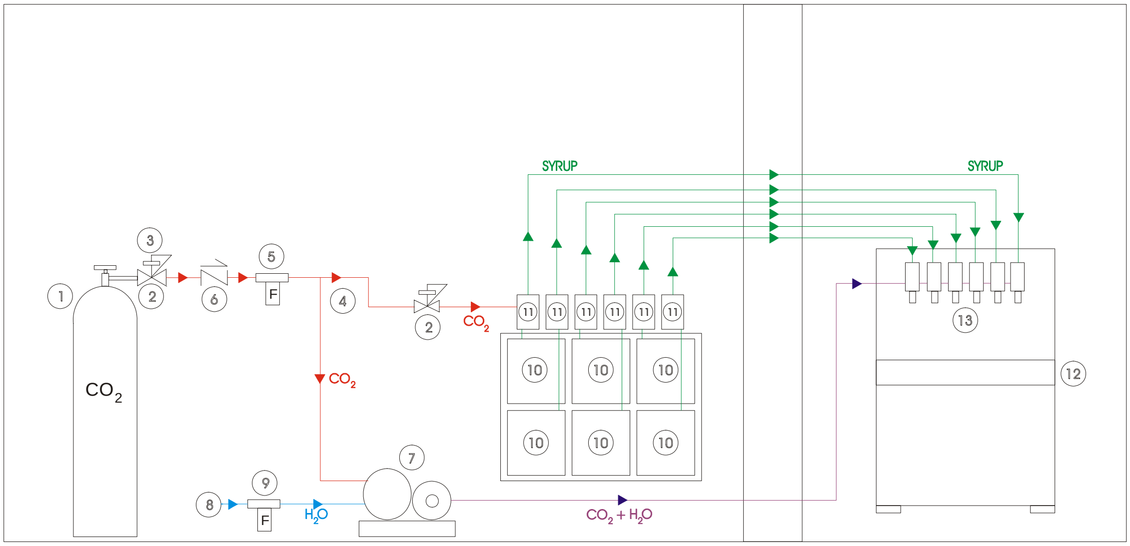

Figure 5: A Typical *Fountain* Dispense Installation

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

CO_2 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 *CO_2* 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 *CO_2* Storage at Users' Premises," for further information on materials of construction.

5 In-line CO_2 Filter/Polisher (Optional)

Where appropriate for the application and recommended by your supplier, an *in-line* CO_2 *filter/polisher* [5] may be installed.

6 Check Valve

A non-return / check valve [6] should be installed before the *carbonator* [7] to prevent any backflow.

7 *Carbonator*

CO_2 passes though a check valve [6], which prevents water from backing up into the CO_2 supply, and fills the *carbonator* tank with CO_2. 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 CO_2 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 CO_2 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.

7.3 Hazard Analysis And Critical Control Point (*HACCP*) Systems, Code of Federal Regulations 21*CFR*120.

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.

7.7 *Code of Federal Regulations* Title 49 *CFR* Parts 100-180 (Transportation), Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, 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

***OSHA* Exposure Classification**	**Limit in Air**
PEL – Permissible Exposure Limit (during 8 hours)	5,000 *ppm*
STEL – Short Term Exposure Limit (during 15 minutes)	30,000 *ppm*
IDLH – Immediately Dangerous to Life and Health	40,000 *ppm*

8.2 Symptoms of CO_2 Exposure

CO_2 Concentration (by volume)	**Symptom – Likely Effects**
1-1.5%	Slight effect on chemical metabolism after exposures of several hours.
3%	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.
4-5%	Stimulation of the respiratory center occurs resulting in deeper and more rapid breathing. Signs of intoxication will become evident after 30 minutes of exposure.
5-10%	Breathing becomes more laborious with headache and loss of judgment.
10-100%	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.

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 CO_2 are summarized in the table below.

8.3.2 Table of CO_2 Properties

Molecular Formula	CO_2
Molecular weight	44.01
Vapor pressure **(uninsulated *cylinder*)**	838 psig at 70°F (57.7 bar at 21°C)
Vapor pressure **(insulated *mini-bulk* container)**	125 psig at –42°F (8.6 bar at –41°C)
Boiling (*Sublimation*) Point at atmospheric pressure	–109°F (–78.5°C)
Specific gravity **(gaseous)**	1.52
Physical State at 70°F (21°C) and atmospheric pressure	Gas
Flammability	Nonflammable

8.4 CO_2 Pressure and Temperature Data

8.4.1 Personnel should be aware of the dangers of potentially high pressures and low temperatures when working with CO_2.

8.4.2 CO_2 in *cylinder*s (*Compressed gas* – UN 1013) is typically at ambient temperature. The pressure in a CO_2 *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 CO_2 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 CO_2 temperature will range from –42°F to +2°F (–41°C to –17°C).

8.4.4 When CO_2 in a *cylinder* or *mini-bulk* container is released to atmospheric pressure, the liquid CO_2 will rapidly boil to form a mixture of gaseous and solid (dry ice) CO_2 at –109°F (–78°C). Contact with liquid CO_2 or the cold gas or solid can cause exposed tissues to freeze.

8.5 *Fountain* CO_2 Purity Guideline

Parameter	Guideline	Rationale[1]
Purity:	99.9 % v/v min.	Process
Moisture:	20 *ppm* v/v max.	Process
Oxygen:	30 *ppm* v/v max.	Sensory
Carbon Monoxide:	10 *ppm* v/v max.	Process
Ammonia:	2.5 *ppm* v/v max.	Process
Nitric Oxide / Nitrogen Dioxide:	2.5 *ppm* v/v max. (each)	Regulatory
Non-volatile Residue:	10 *ppm* w/w max.	Sensory
Non-volatile Organic Residue:	5 *ppm* w/w max.	Sensory
Phosphine:	To pass test (0.3 *ppm* v/v max.)	Regulatory
Total Volatile Hydrocarbons: (as Methane)	50 *ppm* v/v max. including 20 *ppm* v/v max. as total non-methane hydrocarbons	Sensory
Acetaldehyde:	0.2 *ppm* v/v max.	Sensory
Aromatic Hydrocarbon Content:	20 *ppb* v/v max.	Regulatory
Total Sulfur Content* (as S): (*Total sulfur-containing *impurities* excluding sulfur dioxide)	0.1 *ppm* v/v max.	Sensory
Sulfur Dioxide:	1 *ppm* v/v max.	Sensory
Odor of Solid CO_2 (Snow):	No foreign odor	Sensory
Appearance in Water:	No color or turbidity	Sensory
Odor & Taste in Water:	No foreign odor or taste	Sensory

[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 CO_2 Vendor Checklist

This is an example of some recommended questions that could be used to qualify a prospective fountain CO_2 vendor.

CO_2 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. CO_2 Storage Equipment

Does the proposed design meet *ISBT* minimum requirements?

Do all equipment components meet *ISBT* standards?

Are all materials certified to be CO_2 compatible?

Does the equipment comply with minimum *local regulations*?

4. Security

Where applicable, are remote fill boxes secured?

Is CO_2 storage equipment protected from tampering? (*gas cylinders* and *mini-bulk* containers)