Carbon Dioxide Quality Incident Protection Equipment and Confirmation of No Activated Carbon Allergens Risk for;-

‘The Carbonated Beverage Industry’

The issue of Activated Carbon Allergens and the quality of Carbon Dioxide has been a recently discussed hot topic in the soft drinks industry - Dr. Kristopher J. Elliott a Chartered Chemist and Chartered Scientist and David McMillan a Chartered Mechanical Engineer and Fellow of the IMechE both of Parker Hannifin examine the issue in detail.

Introduction

Carbon Dioxide (CO_2) is used in the carbonated beverage industry for carbonation, conveying, packaging and dispensing. The vast majority of carbonated beverage plants purchase their CO_2 from an external source. The purchased CO_2 is delivered complete with quality certification demonstrating that it meets appropriate CO_2 specification. However, the possibility of a quality incident arises from the point of certification along the route the gas has to take before entering into the final product. Process contamination can have a serious detrimental impact upon both the flavour and appearance of the final beverage. In recent years, the importance of carbon dioxide quality and its effects on products has been under close scrutiny on an international scale. Bodies such as the International Society of Beverage Technologists (ISBT) publish strict quality guidelines for the quality of CO_2 used in the carbonated beverage industry. The Carbon Dioxide Quality Guidelines (2010) ensure limits are set for moisture, Oxygen, Carbon Monoxide, Ammonia, Nitrogen Monoxide, Nitrogen Dioxide, Non-volatile Residue, Non-volatile Organic Residue, Total Volatile Hydrocarbons, Acetaldehyde, Aromatic Hydrocarbon, Total Sulphur Content, and Sulphur Dioxide amongst others. In order to address these quality concerns, final multi-layer adsorption filtration has been developed to safeguard against introduction of CO_2 impurities/contaminants and to maintain the quality of the CO_2 as the specification intends. Multi-layer quality incident protection filtration is capable of removing these contaminants to extremely low levels, in order to meet the stringent ISBT limits for all impurities specified. For example, if there was an aromatic hydrocarbon incident where ten times the IBST limit was reached, the multi-layer adsorbent technology would reduce the contamination to less than 20 ppb v/v so the CO_2 can still be used for its intended purpose. The whole carbonated gas industry (from large to small) benefits from this state of the art multi-layer technology, thus guaranteeing full CO_2 quality.

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The Problem

Different chemical production methods employ a diverse array of source chemicals, which can leave several trace impurities in the CO_2. Distribution systems must be rigorously maintained to prevent cross contamination.

Prior to delivery, pure CO_2 is at risk of contamination from leaks, insufficient processing, transportation, storage and handling, which can take place multiple times before reaching its point of use in the production plant.

A range of contaminants could enter the CO_2 distribution system (**Figure 1**). Typical levels of air contaminants are summarised in **Table 1**.[1]

Contaminant	Source	Typical concentration
Dirt particles	Atmosphere	Up to 140 x $10^6/m^3$
Carbon	Burnt oil	Up to 10 mg/m^3
Water	Atmosphere	Up to 11 g/m^3
Rust	Pipework	Up to 4 mg/m^3
Oil	Compressor lubricant	5 – 50 mg/m^3
Oil/water emulsion	Mixture of oil and water	Up to 11 g/m^3
Vapour	Gaseous oil	0.05 – 0.5 mg/m^3
Micro-organisms	Atmosphere	Up to 3850/m^3
Partially combusted hydrocarbons	Atmosphere	Up to 0.5 mg/m^3

Table 1: Atmospheric air contaminants.

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Figure 1: Oil vapour and soot from vehicle exhaust emissions.

Liquid CO_2 prior to its evaporation is an extremely effective solvent in the removal of plasticiser compounds from flexible hoses and gaskets. Rust and pipe scale originating from the presence of water in liquid CO_2 storage tanks and distribution piping can break free and contaminate CO_2 (**Figure 2**)**.**

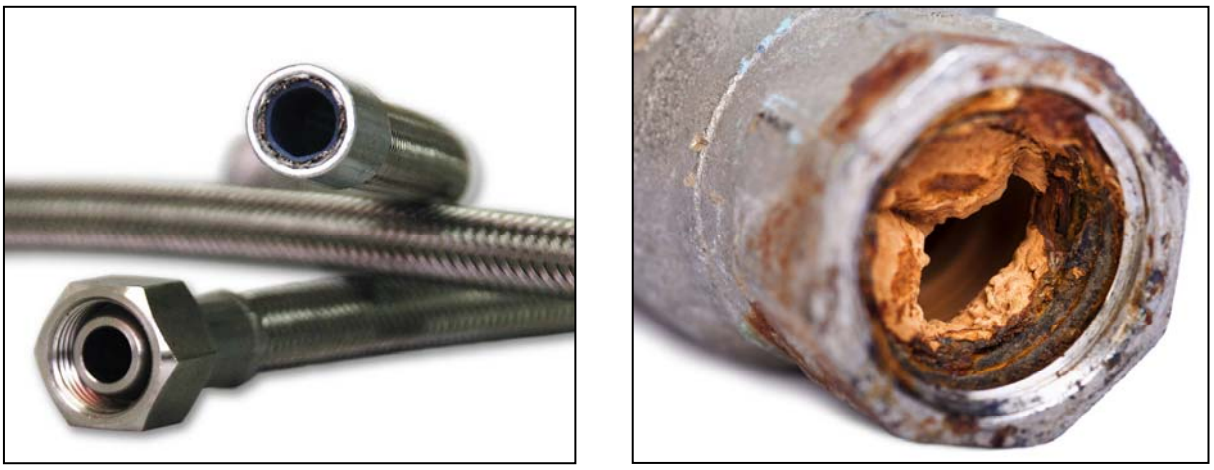

Figure 2*:*

Left: Plasticiser compounds present in flexible hoses can be removed by liquid CO_2.

Right: Rust and pipe-scale formation as a result of moisture ingress.

When CO_2 is loaded, the delivery vehicle is connected to a bulk receiver by a liquid line and a vapour return line (**Figure 3**). If there is an upset in quality anywhere in refinery or distribution system, this dual connection can allow contaminants spread rapidly through an entire distribution system.

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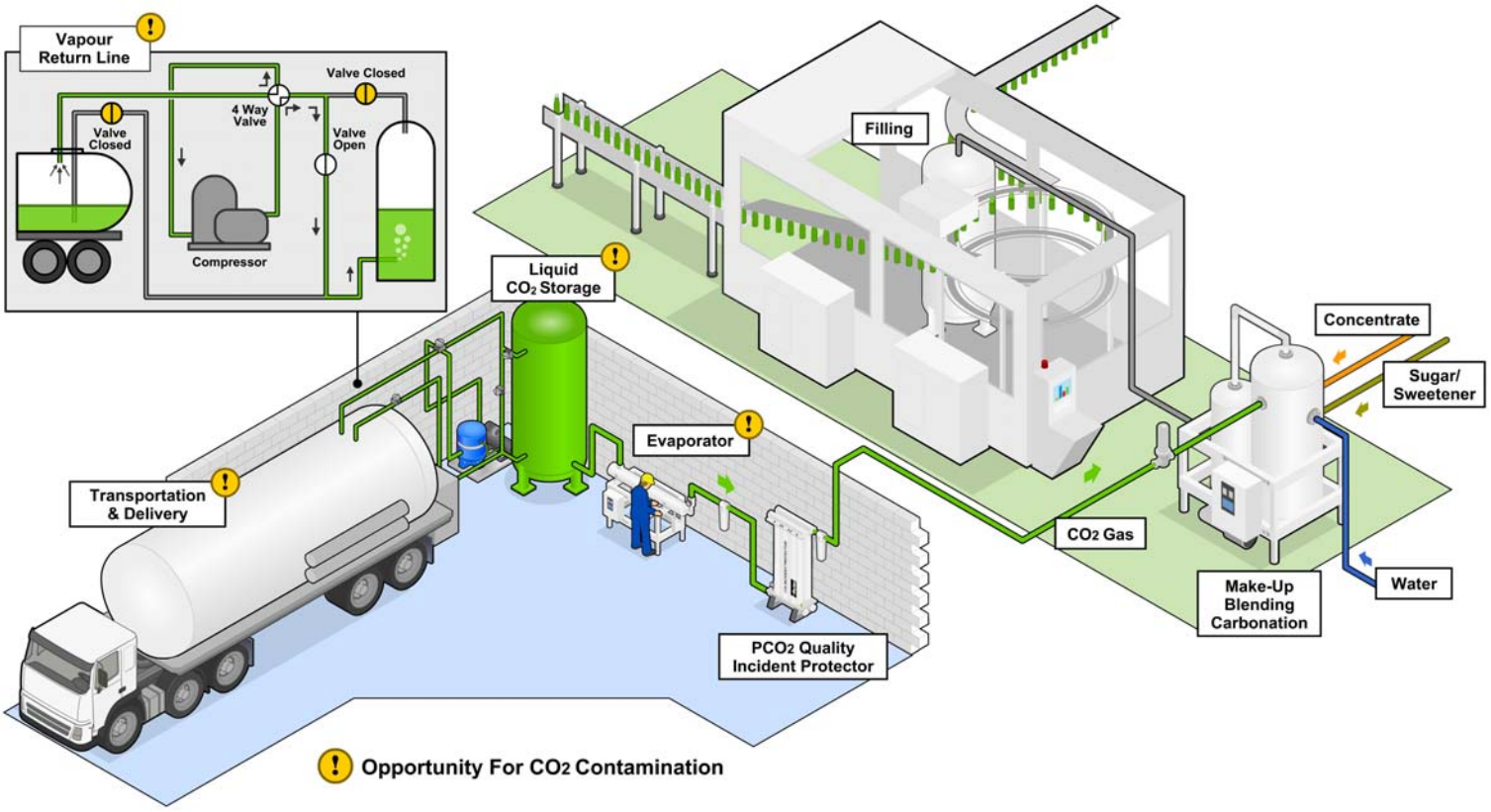

Figure 3*:* Typical vehicle (bulk tank) fill

The Solution

Multiple Stages of Quality Incident Protection

A modular multiple stage quality incident protection system has been developed to offer the highest levels of production plant protection (**Figure 4**).

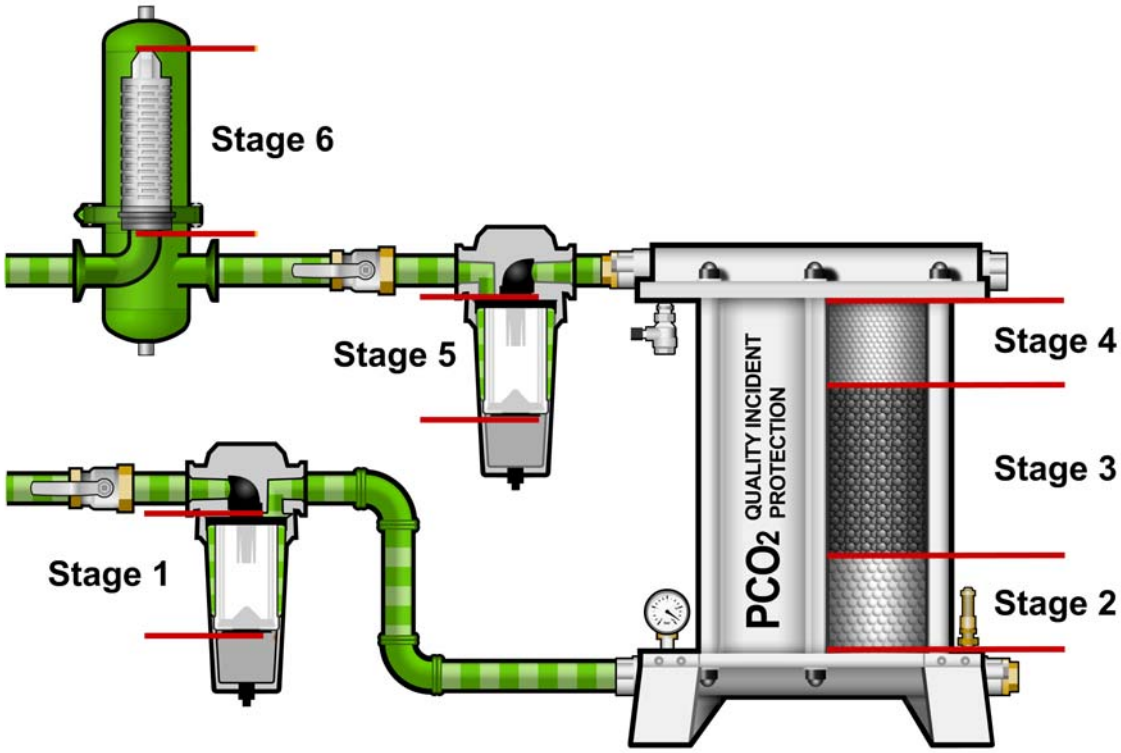

Figure 4: Six stage quality incident protection system.

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Stage 1 – 0.01 micron particle filtration removes NVOR and other contaminants down to 0.01 ppm.

Stage 2 – Removal of water vapour and partial removal of hydrocarbons.

Stage 3 – Primary removal of aromatic hydrocarbons and acetaldehyde.

Stage 4 – Removal of sulphur compounds.

Stage 5 – 0.01 micron particle filtration to prevent adsorbent particulate carryover into CO_2 stream.

Stage 6 – Optional point of use sterile gas membrane filtration is required when the CO2 source or application is at a higher risk from a microbiological perspective.

✔✔ **Good Adsorption**

✓ **Partial Adsorption**

✗ **No Adsorption**

Example Contaminants	Adsorbent Material		
	Stage 2 Adsorbent	Stage 3 Adsorbent	Stage 4 Adsorbent
	Activated Alumina	Activated Carbon	Molecular Sieve
Benzene	✓	✓✓	✓
Toulene	✓	✓✓	✓
Xylene	✓	✓✓	✓
Cyclohexane	✓	✓✓	✓
Acetaldehyde	✓	✓✓	✓
2-Butanone	✓	✓	✓
Dimethyl Ether	✓	✓	✓
Isoamyl Acetate	✓	✓✓	✓
Ethyl Acetate	✓	✓✓	✓
Styrene	✓	✓✓	✓
MIBK	✓	✓✓	✓
Ethanol	✗	✓✓	✓
Methanol	✓	✓✓	✓
Water	✓✓	✓	✓
COS	✗	✓	✓✓
H_2S	✗	✓	✓✓
SO_2	✗	✓	✓✓

Table 2: Contaminant removal in the 3 stages of protection.

It is clear that the presence of multiple stages permits protection against a significantly wider range of contaminants than single-sorbent filters.

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Material Approval and the Food Allergen Labelling Consumer Protection (FALCPA)

An allergen is defined as a substance that causes an allergic reaction. More specifically, it is the proteins in a consumable that cause allergic reactions. An allergen is a type of antigen that produces an abnormally vigorous immune response in which the immune system fights off a perceived threat that would otherwise be harmless to the body.[2]

Tree nuts are among the eight most common food allergens affecting adults and children and are specifically mentioned in the Food Allergen Labeling and Consumer Protection Act (FALCPA) of 2004. This means that the presence of these items must be highlighted, in clear language, on ingredient lists.[3]

In contrast to peanut and tree nut allergies, allergic reactions to coconut are relatively rare. However, there have been reported cases of serious allergic reactions (anaphylaxis). As such it is important that beverage customers are protected from consuming such allergens.[4]

Activated Carbon

Activated carbon is a material that is produced from carbonaceous source materials, such as coal, coconut shell, nutshells, peat, wood, and lignite. Parker beverage quality incident protection systems employ coconut shell based adsorption technology. Activated carbon has an incredibly large surface area per unit volume and a network of submicroscopic pores where adsorption of contaminants can take place. The inclusion of coconut shell derived activated carbon does not pose a coconut allergen threat for the reasons detailed below.

Denaturation of proteins

Since coconut proteins are responsible for causing allergic reactions an outline is provided below detailing how coconut shell derived activated carbon poses no threat to the beverage consumer. Protein three-dimensional tertiary structure is important in protein function. Interactions, such as hydrogen bonding, dictate the tertiary structure of proteins and these intermolecular forces can be disrupted with relatively modest stresses, such as exposure to elevated temperature. Disruption of the protein tertiary structure causes the protein to lose its functionality, a process known as denaturation. The denaturation temperature varies for different proteins, but temperatures above 41°C (105.8°F) will break the interactions in many proteins and denature them.[5,6,7]

Whilst it is highly likely that protein denaturation occurs at temperatures significantly lower than 95°C, coconut protein denaturation was performed during protein functionality studies at 95°C by Lund University researchers.[8] The manufacture of activated carbon involves physical modification and thermal decomposition in a furnace, typically between 700-1100°C under a controlled

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atmosphere.[9,10] Such temperatures significantly exceed the denaturation temperature of the coconut protein, damaging it, which inhibits its ability to act as an allergen. As such, the activated carbon manufacturing process destroys protein based coconut allergens, ensuring their safe use in carbon dioxide quality incident protection systems.

Legislative Response

In addition to detailed literature searches the U.S Food & Drug Administration were also contacted regarding coconut allergens. The FDA response is detailed below:

“Since there is no direct addition of activated carbon (derived from coconut shell) to the final food product (beverage) and carbon dioxide, which will then be used in the production of the beverage, is simply being filtered through the activated carbon, It is not necessary to declare coconut on the label according to the Food Allergen Labeling Consumer Protection Act of 2004(FALCPA)”

“Activated carbon (made of coconut shell) may be safely used in the treatment of food under conditions described in FDA (Food and Drug Administration) 21 CFR 173.25 and would not require a label with regard to the Food Allergen Labeling Consumer Protection Act (FALCPA).”

Furthermore, the supplier of activated carbon was also contacted to clarify the situation and he confirmed that the activated carbon product itself is not a food product. Also they confirmed*, “In terms of the allergens, all complex organic molecules will have been destroyed in the activation process (temperatures between 900-1000°C) so there won’t be any left in the activated carbon”.*

In conclusion, detailed literature reviews combined with both FDA[11] supplier statements and a 3rd party validations conclude that the coconut based activated carbon adsorbent used in the quality incident protection system poses no allergen risk.

All quality incident protection systems are 3rd party validated by an independent testing facility to ensure material compliance to FDA (title 21CFR). The sub sections being 173 - Secondary direct food additives permitted in food for human consumption; 175 - Indirect food additives: Adhesives and components of coatings and 177 - Indirect food additives: Polymers.

Summary

In conclusion, it can be seen that quality incident protection (up to 10 times ISBT specification) is available for the carbonated beverage industry and that the protection system poses no tree nut allergen risk.

By the installation of multi-layer adsorption systems the industry is minimizing risks associated with CO_2 contamination and guaranteeing the final quality of the CO_2.

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11. All components used in the quality incident protection filters conform to the USA's Code of Federal Regulations, Title 21 "Food and Drugs", and 3rd party independent certification attests to this.

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Parker Hannifin Manufacturing Ltd, domnick hunter Filtration & Separation Division is fully supportive of the ISBT and recommends the industry follow their guidelines.

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