Total CO_2 and O_2 Management

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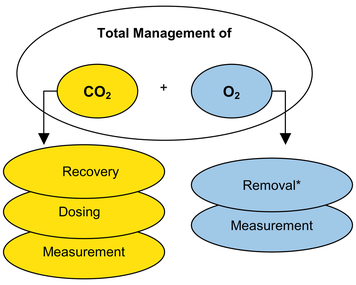
Introduction

Whilst often not regarded as such on first sight, carbon dioxide (CO_2) is referred to as the 5th ingredient of beer, next to the key ingredients water, hop, malt and yeast. It is important to the quality, taste and safety of beer and the same applies to soft drinks. CO_2 recovery, control and dosing are of fundamental importance and should be seen as a total concept of CO_2 Management.

In addition to CO_2, a second gas of major importance in the beverage industry is oxygen (O_2). O_2 is highly detrimental to beverages, because of its negative effects on both shelf life and flavor stability. Nowadays, the nearly indefinite choices of flavors and the use of ever more sensitive ingredients re-quire lowest oxygen level in beverages. O_2 control and removal are fundamental importance and should be seen as a total concept of O_2 Management.

A reliable CO_2 & O_2 management is therefore an important aspect during and after the beverage production.



** with exception of wort aeration/yeast propagation*

Figure 1: Total CO_2 and O_2 Management

Managing CO_2 and O_2 in CO_2 gas from recovery

CO_2 Recovery plays an important role in the concept of Total CO_2 & O_2 Management. The demand for CO_2 of good quality continues to grow. To meet this de-mand new technologies are developed to improve the CO_2 quality, recovery rates and efficiency.

CO_2 Recovery

In the recovery process of CO_2 (figure 2) three main steps can be defined: purification, liquefaction and storage.

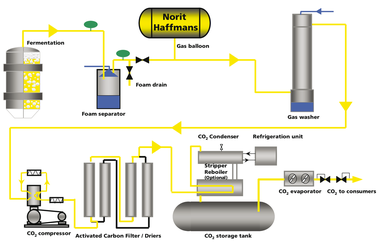


Figure 2: CO_2 Recovery Process

During the purification process undesired components such as beer foam, water-soluble components as alcohol and extract, odors and sulphur components and water are removed from the CO_2. Furthermore, during CO_2 liquefaction none condensable gasses (O_2 and N_2) are separated and purged. The end quality is depending of the type of CO_2 recovery installation as shown in table 1.

CO_2 recovery sytems	CO_2 Inlet CO_2 % Vol	CO_2 Outlet CO_2 % Vol
Conventional	> 99.7	> 99.97
LO (Low Oxygen)	> 99	> 99.998 / O_2 < 5 ppm
HLP	> 95	> 99.998 / O_2 < 5 ppm

Table 1: Recovery Rates

The main advantage is that fermentation CO_2 pro-duced from beer or other fermentation processes itself guarantees that the recovered CO_2 is fundamentally food-grade. This makes the CO_2 suitable for protecting the beer against O_2 pick-up in tanks, production lines, carbonation and packaging. Furthermore a CO_2 surplus can be sold to other high purity CO_2 users, such as soft drink bottlers.

Water deaeration

To avoid oxygen pick-up during the production, beside the high purity CO_2 measures should be taken such as the usage of only deaerated water and in the entire process, with special attention for the water used for blending.

Different methods of water deaeration are used with its typical concentrations of O_2 as shown in table 2.

Water Deaeration		O_2
Water Deaeration System (based on stripping technology)	Hot Cold	< 20 ppb < 50 ppb
Water Deaeration System (based on membrane technology)		< 5 ppb

Table 2: Typical O_2 values of Water Deaeration Systems

The water deaeration system based on membrane technology is attractive to the other existing water deaeration systems due to:

- any water capacity and
- any residual oxygen level can be achieved.

These advantages make membrane technology a very attractive alternative compared to other technologies, which usually involve bulky equipment, considerable investment costs and high-energy consumption.

Carbonation (dosing) / Blending

The CO_2 content in beer that comes from the fermen-tation/maturation process is not always within specification and additional carbonation is necessary. It's of high importance that the carbonation process is done properly enough to avoid a later break-out of CO_2. Reliable measuring systems for CO_2/O_2 should be used.

Benefits

- Bubble free carbonation
- Wide capacity range
- Fully automotive

For High Gravity brewing, a combination of a blending system and carbonation is often used. In one step the CO_2 gas is bubble free dissolved and the water and beer homogeneously mixed. The use of deaerated water is essential to avoid O_2 pick-up. Again CO_2 and O_2 measurements play a key roll in this process.

O_2 portion in CO_2 gas *[ppm v/v]*	O_2 increase in beer *[ppm g/g]*	CO_2 purity *[% v/v]*		
		20% O_2 80% N_2	40% O_2 60% N_2	60% O_2 40% N_2
1	0,0007	99,9995	99,9998	99,9998
5	0.0037	99,9975	99,9988	99,9992
10	0,0073	99,995	99.9975	99,9983
20	0,0145	99,99	99,995	99,9967
40	0,0290	99,98	99,99	99,9933
60	0,0436	99,97	99,985	99,99

Table 3: Oxygen pick-up vs. CO_2 purity

CO_2 & O_2 Measurement

In the beer and beverage industries CO_2 and O_2 are key parameters for the quality assurance and product safety in a production environment. It's therefore important to use reliable measurement systems to monitor these key parameters. In the figure below gives an overview where CO_2 and O_2 should be measured.

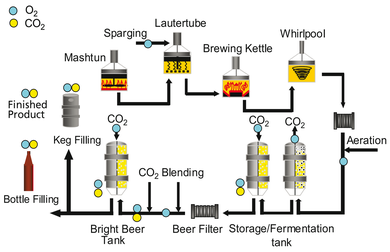


Figure 3: Recommended positions of CO_2 & O_2 measurement

CO_2 Measurement

There are several methods to measure CO_2 in the beer and beverage industry. The CO_2 measurement technology based on Henry's Law is the most reliable accepted and widely used method in the industry.

O_2 Measurement

The traditional methods that are used to measure O_2 in the beer and beverage industry are based on Clark-cell technology. Recently, a new optical O_2 measuring technology has been validated and accepted by brewing institute Weihenstephan. Compared to traditional dissolved O_2 measurement technology, the new method excels through:

- Quick response times,
- Highest accuracy at even lowest oxygen levels,
- Low maintenance and calibration efforts,
- And long-term stability.

Conclusion:

Total CO_2 & O_2 Management is an important aspect during and after production!!

CO_2 and O_2 are of major importance to the quality and safety of the end product. A reliable and predictable CO_2 & O_2 management is therefore an important aspect during and after the beverage production process as you can see in the table below.

	CO_2			O_2	
	Recovery	Dosing	Measurement	Removal	Measurement
Sparging					x
Yeast Propagation				x*	x
Wort Aeration				x*	x
Fermentation	x		x	x	
Maturation			x		x
Filtration					x
Carbonation / Blending		x	x		x
Bright Beer Storage			x		x
Packaging			x		x
Lab			x		x

Table 4: Total CO_2 and O_2 Management

Using accurate and reliable measuring techniques and equipment is very important. Norit Haffmans developed a complete range of products that take care of the Total Management of your CO_2 & O_2.

- **CO_2 Recovery and O_2 control in CO_2 gas**
- **CO_2 Analysis Service**
- **CO_2 Audits**
- **Water deaeration**
- **Bubble free' carbonation for 'dissolving of CO_2 in liquid**
- **In-line and at-line CO_2 and O_2 control and measurement during various production steps**
- **Measurement of CO_2 and O_2 in the final product filled in bottles, cans or keg.**

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