Keywords: Carbon dioxide, drink, brewing, wine, detector, detection, monitor gas, CO_2, hazard, health & safety, toxic, protect, workforce

Detect and protect against carbon dioxide

Simon Boulter
Training Officer
Crowcon Detection Instruments Ltd, UK
simon.boulter@crowcon.com

Abstract

The danger associated with carbon dioxide (CO_2) in the drinks industry is well known. This gas is toxic, but the nature of the threat it poses is not always fully understood. Many national regulatory bodies set exposure limits above which employees must not be exposed[1,2,3]. People die needlessly every year in tragic and completely avoidable accidents. Use of personal gas protection devices designed to detect CO_2 is necessary to protect human life.

Introduction

Carbon dioxide is ubiquitous through-out the drinks industry, including carbonated soft drinks, wines and lager. Carbonation of soft drinks can occur at many points along the production and logistics process, from the bottling process or the point of sale at a consumer outlet. In the brewing and wine-producing industries, CO_2 is a by-product of the fermentation processes, as well as a raw material for lager and some sparkling wines.

There is a misconception among some that, by monitoring oxygen (O_2) levels, they are effectively protecting themselves against CO_2. This is not the case, however. Reliance on monitoring levels of oxygen to protect against carbon dioxide has led to fatalities[4].

Another error is to think that CO_2 can be detected by smell or taste[5]. Again, this is not the case. It is not possible to detect the presence of CO_2 other than by use of the right detection equipment.

Properties and effects of CO_2

CO_2 is heavier than air. It is a hazard throughout the manufacturing process, right through to packaging and bottling and even to the bars and eating establishments where the drinks are served. If CO_2 escapes, it will tend to sink to the floor, where it can form deadly, invisible pockets. It collects in cellars and at the bottom of containers and confined spaces such as tanks and silos.

> "Reliance on monitoring levels of oxygen to protect against carbon dioxide has led to fatalities[4]."

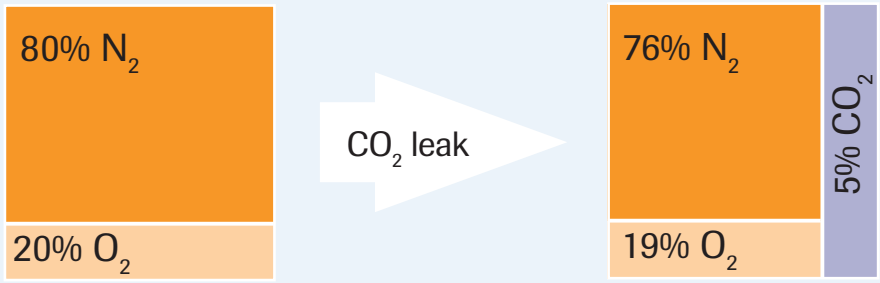
CO_2 is extremely hazardous and can kill in two ways:

- **By displacing O_2, leading to rapid asphyxiation:**
  Asphyxiation can be caused by any gas displacing O_2 leaving you with no oxygen to breathe in the atmosphere
- **As a toxin:**
  Not all gases are toxic. However, exposure to as little as 0.5% by volume CO_2 represents a toxic health hazard[1,2,3], while concentrations greater than 10% by volume can lead to death[6]. Because CO_2 is completely odourless and colourless, there may well be no indication of danger until it is too late.

Carbon dioxide displacement of atmospheric gases

Monitoring O_2 levels will help protect you against asphyxiation, but it is a poor precaution against the toxic effects of lower levels of CO_2. At almost 80% volume, nitrogen (N_2) comprises the majority of normal air. This means that, if a CO_2 release occurs, most of the gas that it displaces will be N_2 (fig 1). Therefore, in the event of a leak of CO_2, the percentage increase of CO_2 is not matched by a similar decrease in the O_2 concentration. Carbon dioxide can reach exposure limit levels, but O_2 levels could still be comparatively unaffected and so considered safe. An additional danger in this case is that, with high concentrations of CO_2, some oxygen sensors give a small upscale signal[4], i.e. a falsely high reading.

Fig 1: CO_2 displacement of atmospheric gas



"Whichever gas monitor you choose, the importance of maintenance and calibration can't be overemphasised."

Exposure Limits

While the data on the toxic effects of CO_2 are interpreted slightly differently in different jurisdictions, there is little meaningful difference. Table 1 details extracts from one such set of guidance, from Health Protection England.

Many countries set statutory workplace exposure limits to protect against the effects of a toxic gas.

These are generally defined in two ways:

- **Short Term Exposure Limit (STEL)** - maximum allowable concentration over a shorter time period, usually 15 minutes
- **Long Term Exposure Limit (LTEL)** - calculated as an 8-hour time weighted average (TWA)

The TWA for CO_2 tend to be set around 0.5%[1,2,3], with STEL of between 1.5%[2] to 3.0%[1,3].

The TWA concept is based on a simple average of worker exposure during an 8-hour day. It permits periods of exposure above the TWA limit, but only as long as the STEL is not exceeded and there is equivalent under-exposure to compensate.

Table 1: the toxic effects of CO_2 on the human body at different concentrations

Percent CO_2	Symptoms
2%	Headache and laboured breathing
5%	Headache, shortness of breath, dizziness, confusion, respiratory distress
8% – 10%	Severe headache, sweating, dimness of vision, tremor and loss of consciousness in 5 – 10 mins.
10%	Difficulty breathing, vomiting, hypertension. May be fatal
20% – 30%	Exposure can cause convulsions and coma within 1 minute

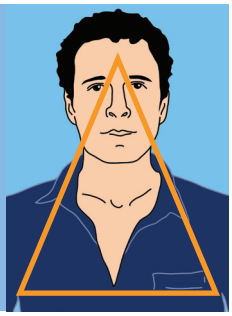
Ensure compliance – keep safe

So, in an environment where CO_2 is used in many different ways and likely to be regularly encountered, even if at low levels, how can people be protected from toxic exposure?

- **Use personal monitors**
  In order to ensure compliance with occupational exposure limits calculated as TWAs, it is necessary to monitor the levels of CO_2 each worker is exposed to, individually. To achieve this, personal monitors are required.

- **Monitor in the breathing zone**
  As the device is to monitor the air that the staff member is inhaling, it is vital that the unit is worn close to the breathing zone. This could be achieved by wearing it on the collar or breast pocket, but not on a belt or trouser pocket. Breathing on it directly must be avoided, however, as this could set it into alarm.

"It is vital that the unit be worn in the breathing zone."



- **User-friendly monitoring**
  Use of units that are light and compact enough to wear for an entire shift will encourage compliance. A bulky unit would be uncomfortable, and could even be an impediment to freedom of movement.

- **Keep it simple**
  When it comes to keeping safe, a detector with a clear display and simple one-button operation is best. This makes it easy to train people to use it. On the (hopefully) rare occasion the unit goes into alarm, they will be better able to remember and follow the training.

- **Don't miss the warning signs**
  A detector should combine powerful audible and visual signals to warn when pre-set gas levels are reached, to alert the wearer even in a noisy environment. If a unit goes into alarm, how to react will depend on the level at which the alarm is set. Make sure everyone knows what they should do under which circumstances.

- **IR is best for CO_2**
  Infrared (IR) sensors are more robust sensors, better suited for this application. They have a much longer life compared to other commonly used sensor types, making them more cost-effective. They are also not affected by high levels of gas, which some other sensors can be.

- **Ensure reliability**
  Clearly, life-saving tools for demanding environments must be as tough as possible, with reliable electronics housed in impact-resistant casings. While the need to leave gas sensors exposed to the atmosphere means that no instrument can be fully sealed, a high degree of protection against dust and water ingress is essential.

- **Maintain**
  Which ever gas monitor you choose, the importance of maintenance and calibration can't be overemphasised. Regular checking with gas (bump testing) is the only way to check that a detector reacts correctly to exposure to the relevant gas, and it should be a routine part of device maintenance.

Summary

Carbon dioxide is a deadly toxic gas. Elevated levels can kill, and every year people in the drinks industry die from CO_2 inhalation. This can be avoided. Use of today's CO_2 gas detection technologies, and adherence to recognised best practice, should be at the top of your health and safety agenda.

The message is clear, detect and protect.

For more information, visit www.crowcon.com/industries-and-applications/winery-and-brewery-industries.html

"Make sure everyone knows what they should do under which circumstances."

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www.crowcon.com

UK:
Tel: +44 (0) 1235 557700
Fax: +44 (0) 1235 557749
Email: sales@crowcon.com

US:
Tel: +1 859 957 1039
Toll Free: 800-527-6926
Fax: +1 513 957-1044
Email: salesusa@crowcon.us

NL:
Tel: +31 10 421 1232
Fax: +31 10 421 0542
Email: eu@crowcon.com

SG:
Tel: +65 6745 2936
Fax: +65 6745 0467
Email: sales@crowcon.com.sg

CN:
Tel: +86 (0) 10 6787 0335
Fax: +86 (0) 10 6787 4879
Email: saleschina@crowcon.com

IN:
Tel: +91 22 6708 0400
Fax: +91 22 6708 0405
Email: salesindia@crowcon.com

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