CROWCON
Detecting Gas Saving Lives

Crowcon Whitepaper

Don't die from carbon dioxide poisoning

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.

Simon Boulter

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

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.

Drinks manufacturers have woken up to the threat from CO_2 in their production facilities, using appropriate gas detection equipment and providing training to staff. There is less likely to be a real appreciation of the hazards to their staff from a gas cylinder leak when in the cellars of bars and food outlets.

There is still a misconception among some that, by monitoring oxygen (O_2) levels, they are effectively protecting themselves gainst CO_2. This is not the case, however. Reliance on monitoring levels of oxygen to protect against CO_2 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. According to the Guidance Note 30 of the British Compressed Gases Association, most cellars are classified as confined spaces due to their design, size, ventilation, etc[6].

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CO_2 is extremely hazardous and can kill in two ways:

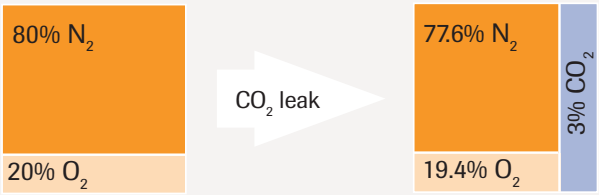
By displacing O_2, leading to rapid asphyxiation:
Asphyxiation can be caused by any gas displacing O_2 leaving you with no oxygen to breathe in the atmosphere

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[7]. Because CO_2 is completely odourless and colourless, there may well be no indication of danger until it is too late.

CO_2 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



Exposure limits

Studies show that even in the presence of normal concentrations of oxygen, exposures to 7% CO_2 can cause death in only 5 minutes[8]. 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 CO2 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.

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

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

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 being poisoned?

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 essential.

Use of TWAs can also avoid spurious alarms, which cause unwarranted disruption. This prevents complacent attitudes that spurious alarms are recognized to cause9, which can result in staff ignoring alarms and not turning on detectors. It should also improve operational efficiency.

Monitor in the breathing zone

The detector should monitor the air that the staff member is inhaling. To do this effectively, it must be worn in the breathing zone, e.g. on the collar or breast pocket; not on a belt or trouser pocket.

Breathing on it directly must be avoided, however, as this could set it into alarm.

User-friendly monitoring

A light and compact detector will encourage compliance. A bulky unit can be uncomfortable, and could impede freedom of movement in a confined space, which must be avoided.

Keep it simple

When it comes to keeping safe, a detector with a simple one-button operation and clear display is best. It makes training much easier. This means that, on the (hopefully) rare occasion the unit goes into alarm, staff will be better able to remember and follow the training correctly. This saves lives.

If the alarm does go off, 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.

Don't miss the warning signs

Some production areas are very noisy. A detector must combine powerful audible and visual signals to be sure the wearer is immediately alerted to danger, even in a noisy environment.

IR is best for CO_2

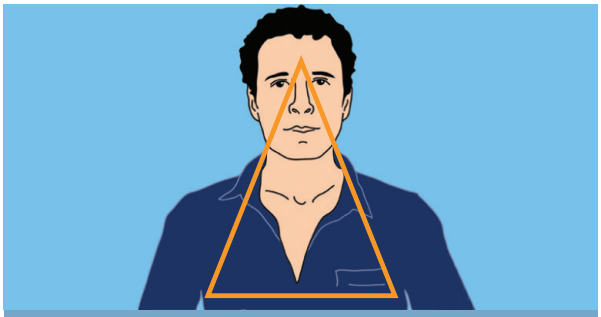
Infrared (IR) sensors are better suited for by the drinks industry. They are not affected by high levels of gas, which some other sensors can be, making them more accurate and reliable. IR sensors are more robust, too. Their much longer life compared, to other commonly used sensor types, also makes them more cost-effective.

Ensure reliability

Clearly, life-saving tools for such a demanding environment must be tough, 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

Whichever 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 when in contact with gas, and it should be a routine part of device maintenance.



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

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

Conclusion

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. Choose the right gas detector - don't die from CO_2 poisoning.
For more information, visit www.crowcon.com/industries-and-applications/winery-and-brewery-industries.html

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www.crowcon.com

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

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

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

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

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

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