Don’t die from carbon dioxide poisoning

Abstract

The danger associated with carbon dioxide (CO₂) 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 exposed¹,²,³. People die needlessly every year in tragic and completely avoidable accidents. Use of personal gas protection devices designed to detect CO₂ is necessary to protect human life.

Introduction

Carbon dioxide is ubiquitous throughout 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, CO₂ 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 CO₂ in their production facilities, using appropriate gas detection equipment and provide 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 (O₂) levels, they are effectively protecting themselves against CO₂. This is not the case, however. Reliance on monitoring levels of oxygen to protect against CO₂ has led to fatalities⁴.

Another error is to think that CO₂ can be detected by smell or taste⁵. Again, this is not the case. It is not possible to detect the presence of CO₂ other than by use of the right detection equipment.

Properties and effects of CO₂

CO₂ 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 CO₂ 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, etc⁶.

CO₂ IS EXTREMELY HAZARDOUS AND CAN KILL IN TWO WAYS:

• By displacing O₂, leading to rapid asphyxiation:
  Asphyxiation can be caused by any gas displacing O₂ 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 CO₂ represents a toxic health hazard⁷,⁸, while concentrations greater than 10% by volume can lead to death⁹. Because CO₂ is completely odourless and colourless, there may well be no indication of danger until it is too late.

“Reliance on monitoring levels of oxygen alarms to protect against carbon dioxide has led to fatalities⁴.”
Carbon dioxide displacement of atmospheric gases

Monitoring O₂ levels will help protect you against asphyxiation, but it is a poor precaution against the toxic effects of lower levels of CO₂. At almost 80% volume, nitrogen (N₂) comprises the majority of normal air. This means that, if a CO₂ release occurs, most of the gas that it displaces will be N₂ (Fig 1). Therefore, in the event of a leak of CO₂, the percentage increase of CO₂ is not matched by a similar decrease in the O₂ concentration. Carbon dioxide can reach exposure limit levels, but O₂ levels could still be comparatively unaffected and so considered safe. An additional danger in this case is that, with high concentrations of CO₂, some oxygen sensors give a small upscale signal, i.e. a falsely high reading.

Fig 1: CO₂ displacement of atmospheric gas

Exposure Limits

Studies show that even in the presence of normal concentrations of oxygen, exposures to 7% CO₂ can cause death in only 5 minutes. While the data on the toxic effects of CO₂ 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% to 3%, with STELs of between 1.5% to 3.0%. 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.

“Whichever gas monitor you choose, the importance of maintenance and calibration can’t be overemphasised.”
Ensure compliance – keep safe

So, in an environment where CO₂ 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 CO₂ 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.

<table>
<thead>
<tr>
<th>Percent CO₂</th>
<th>Symptoms</th>
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<tbody>
<tr>
<td>2%</td>
<td>Headache and laboured breathing</td>
</tr>
<tr>
<td>5%</td>
<td>Headache, shortness of breath, dizziness, confusion, respiratory distress</td>
</tr>
<tr>
<td>8% – 10%</td>
<td>Severe headache, sweating, dimness of vision, tremor and loss of consciousness in 5 – 10 mins.</td>
</tr>
<tr>
<td>10%</td>
<td>Difficulty breathing, vomiting, hypertension. May be fatal</td>
</tr>
<tr>
<td>20% – 30%</td>
<td>Exposure can cause convulsions and coma within 1 minute</td>
</tr>
</tbody>
</table>

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

• **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 CO₂**

Infrared (IR) sensors are better suited for 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.
Summary

Carbon dioxide is a deadly toxic gas. Elevated levels can kill, and every year people in the drinks industry die from CO₂ inhalation. This can be avoided. Use of today’s CO₂ 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 CO₂ poisoning.

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

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