British Beer and Pub Association
Carbon Dioxide in Cellars
Guidance Note for Licensees

Introduction

Carbon Dioxide (CO\textsubscript{2}), and Mixed Gas (a mixture of CO\textsubscript{2} and Nitrogen (N\textsubscript{2})), is supplied in cylinders containing the gas partly as liquid and partly as gas under pressure.

Mixed gas is increasing in usage, and will normally be used in one of the following ratios – 30/70, 50/50 or 60/40, where the ratios are percentage volume of CO\textsubscript{2} to N\textsubscript{2}. In this guidance note all cylinders will be assumed to contain 100\% CO\textsubscript{2}, for greater safety.

Normal operating procedures should not result in the CO\textsubscript{2} concentration in the cellar rising above the Occupational Exposure Standard of 0.5\%, and working time in the cellar would never normally average out at 8 hours in a working day.

It is very important to only purchase gas from reputable suppliers, since the cylinder itself could explode if moisture is introduced, if the wrong specification cylinder is used or if the relevant safety checks are not carried out before filling. When purchased from reputable suppliers, the greatest risk is presented if the safety disk in the gas cylinder ruptures.

CO\textsubscript{2} cylinders are designed and regularly tested, to withstand very high pressures and are provided with a safety bursting disc in the "on/off" valve. Accidental ‘over pressure’ might occur if the cylinders are left for long periods near heat sources (eg boiler room), or are dropped and/or damaged. The primary regulating valve also contains two safety pressure relief valves, which will allow a controlled release of gas should there be a problem with excessive pressures in the system.

If a safety disc ruptures (catastrophic failure) there will be a sudden noisy release of gas, in the form of a dense white cloud. The colour results from frozen CO\textsubscript{2} and condensed water vapour, and is only visible when the gas is initially released. It is extremely cold and should not be touched. Once the disc has ruptured, the release cannot be stopped and will continue until the cylinder is empty. The release of gas is not instantaneous however, since rapid discharge will freeze about 30\% of the gas inside the cylinder, which will then be slowly released over several hours.

CO\textsubscript{2} is a colourless gas with a slightly pungent odour at high concentrations. It does not support combustion, is heavier than air and will dissolve in water, forming a weak acid. Since CO\textsubscript{2} is heavier than air, it will tend to concentrate at floor level and will disperse throughout the available floor area – this could prove hazardous in small, single room underground pit-cellsars. Refrigeration fans and the violence of the gas release itself, will cause the escaped gas and air in the room to become mixed, but there will be a tendency for the CO\textsubscript{2} to drop near the floor, underneath the warmer, lighter air in the room.

Air changes will occur in all cellars, due to the inherent structure and use of the room ie cellar drop area, gaps in walls and floors for pipes and services etc. The regular circulation of air by the refrigeration fans and open doors or cellar flaps will also increase air changes.

When cellars are at or above ground, significant air changes will occur whenever the door is opened, - especially when combined with the circulation factor associated with the refrigeration fans.
**Legislation**

Legislation requiring risk assessment of all hazards has been in existence for many years. The Health and Safety at Work Act, the Control of Substances Hazardous to Health Regulations and the Management of Health and Safety at Work Regulations all require the consideration of hazards and subsequent risk. As a result of this, most public houses already have a safe working procedure for cellars and CO₂ in place.

The Confined Spaces Regulations came into force on the 28th January 1998 and apply across all industry sectors, requiring the employer to assess the risks connected with entering or working in a confined space. A safe working procedure should be devised to remove or reduce significant risks.

The regulations apply to all confined spaces, as defined in the HSC Approved Code of Practice on Safe Work in Confined Spaces 1997 (L101).

Under the regulations, a confined space is deemed to be: -

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“any place, including any chamber, tank, vat, silo, pit, trench, pipe, sewer, flue, well or other similar space in which, by virtue of its enclosed nature, there arises a reasonably foreseeable specified risk.”
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Under the regulations, a "specified risk" means a risk of: -

a) serious injury to any person at work arising from a fire or explosion;

b) without prejudice to the above –
   i) the loss of consciousness of any person at work arising from an increase in body temperature;
   ii) the loss of consciousness or asphyxiation of any person at work arising from gas, fume, vapour or the lack of oxygen;

c) the drowning of any person at work arising from an increase in the level of a liquid; or

d) the asphyxiation of any person at work arising from a free flowing solid or the inability to reach a respirable environment due to entrapment by a free flowing solid.

**Application of the Confined Spaces Regulations**

Loss of consciousness or asphyxiation arising from a lack of oxygen, or the toxic effects of CO₂ as a result of a cylinder safety disk rupturing, are identifiable hazards.

However, serious incidents involving gas in pub cellars are extremely rare. Therefore, whilst there is an identifiable hazard, the actual associated risk is very small.

The majority of pub cellars should not present a “reasonably foreseeable specified risk” and therefore will not attract the detailed requirements of the regulations.

In order to confirm and clarify this, licensees should complete an appropriate risk assessment, and devise or review their safe working procedures where necessary.

A comprehensive safe working procedure effectively trained to all staff should adequately reduce operational risks, and should be adopted regardless of whether the Confined Spaces Regulations apply or not.

Refer to Appendix A for a sample Safe Working Procedure.
Risk Assessment - the following information should be considered:

- The risk of a serious gas leak from the **pipework** is highly unlikely, providing the system complies with the Pressure Systems Safety Regulations 2000 and pipework is protected from physical damage by position or protective trunking where necessary.

- The risk of a serious gas leak from **keg couplers** is also highly unlikely, and management controls during the normal operation of the cellar eg. changeover of barrels etc will ensure that even that risk is minimised.

- The risk of a serious gas leak is therefore most likely from the **safety disk on the cylinder** itself or from the **primary regulator valve**. Both items are subject to stringent statutory checks, and the likelihood of a failure (based on the quality checks and the past safety record) is very low.

- It is reasonable to assume that there may be a serious gas leak from **only one gas cylinder** at any one time. This may not apply to older systems where two or more cylinders are connected to a manifold. In those instances, it is necessary to assume that all cylinders connected and open will release their contents. Recent manifold arrangements include a changeover valve and will only release the cylinder in use.

- It is reasonable to assume that the **largest cylinder** on site is the one to use for the calculations, since this presents a worst case scenario – ie that the cylinder is full.

- It is reasonable to assume that if the gas cylinders and primary regulator are **situated external** to the building, the risk of a serious gas leak in the cellar is negligible.

- It is reasonable to assume that if the gas cylinders and primary regulator valve are situated in the building but in a well ventilated room, **separate from the beer cellar** and other storage areas, the risk of a serious gas leak in the beer cellar is negligible.

- It is reasonable to assume that if the beer cellar is one room in a **larger cellar area**, low level ventilation under doors and through air bricks etc. will result in the dilution and dispersal of the gas throughout the entire floor area over a relatively short period of time.

- It is reasonable to assume that in most public houses, if a safety disc **bursts during trading hours**, staff will be aware of the commotion as the gas is released suddenly and very loudly. Drink service will also be directly affected if the cylinder in use is the one at fault.

The recommended method of completing a cellar risk assessment is detailed below. It is a two stage procedure, principally aimed at calculating the worst case scenario, of the largest gas cylinder on site releasing its contents into the room.

The first stage is for the licensee to use this information to decide if the beer cellar is high risk or not. If the first stage assessment falls within acceptable limits, the licensee must implement a suitable safe system of work and review it as necessary.

If the first stage assessment raises concerns, it is recommended the licensee requests a visit from the pressure system owner (or other competent person) for advice. A competent person will then review and amend as necessary, the first assessment. Refer to Appendix B for a decision tree of the necessary steps.
First Assessment

The Licensee should estimate the gross volume of air in the below ground beer cellar - and adjacent rooms if low level air circulation is possible between the rooms. Record the details in the following table to indicate whether the first action level is reached. The action level is based on the concentration of CO\textsubscript{2} not exceeding 4 %. Refer to Appendix C for details of the symptoms of CO\textsubscript{2} exposure at varying concentrations.

To establish the gross volume of air, pace out the length and width of each room – a normal pace will equal approximately 3 feet. Multiply the width by the length by the ceiling height for the gross volume of air in the room – ie volume = width x length x height. If more than one room is being used for the calculation, add the gross volumes together.

<table>
<thead>
<tr>
<th>Cylinder Size In Use</th>
<th>Minimum Volume of Space Required</th>
<th>Gross Volume of Air Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1kg (7lb) CO\textsubscript{2}</td>
<td>57m\textsuperscript{3}</td>
<td>2,000 ft\textsuperscript{3}</td>
</tr>
<tr>
<td>6.3kg (14lb) CO\textsubscript{2}</td>
<td>110m\textsuperscript{3}</td>
<td>3,800 ft\textsuperscript{3}</td>
</tr>
<tr>
<td>12.7kg (28lb) CO\textsubscript{2}</td>
<td>215m\textsuperscript{3}</td>
<td>7,600 ft\textsuperscript{3}</td>
</tr>
<tr>
<td>25.4kg (56lb) CO\textsubscript{2}</td>
<td>425m\textsuperscript{3}</td>
<td>15,000 ft\textsuperscript{3}</td>
</tr>
<tr>
<td>34kg (75lb) CO\textsubscript{2}</td>
<td>570m\textsuperscript{3}</td>
<td>20,000 ft\textsuperscript{3}</td>
</tr>
</tbody>
</table>

Tick the column for the largest CO\textsubscript{2} cylinder in use and compare the minimum volume of space required against the actual gross volume measured. Keep measurements in either feet or metres and refer to Appendix D for clarification on the calculations required.

Where the gross volume of air is more than the minimum volume of space indicated, there is not a reasonably foreseeable risk, due to the general dispersion of the gas. A safe working procedure, management controls and staff training will ensure that any element of risk is controlled. See appendix A for a sample safe working procedure.

However, it is still desirable to reduce the risk as much as reasonably practicable, so the following issues should be considered, and advice sought from a competent person such as the pressure system owner, gas supplier or principal beer provider as necessary:

- Ensure dispense equipment is properly installed and maintained
- Reduce the maximum cylinder size
- Keep storage stocks to an absolute minimum and store in a well ventilated area
- Do not ‘manifold’ cylinders together in use, utilise a changeover valve
- Instruct all staff in the safe use of dispense gases, paying particular attention to management controls, safe working procedures, symptoms of CO\textsubscript{2} exposure etc.
- Leave the cellar door open when going in to change over barrels
- Subject to fire safety requirements – eg boiler rooms, plant rooms etc, leave doors to other adjacent rooms open wherever possible, obviously not the cellar itself
- Display the BBPA dispense gases warning poster
- Consider relocating the gas cylinders and primary valve externally or in a separate well ventilated area
- Consider improving general ventilation in the below ground area with ‘air brick’ connections to outside and/or adjacent rooms
- In small, single room, single access underground pit-cellars, with no possibility of improving ventilation input and air circulation, refer to a competent person for advice on the installation of gas detection alarms
Appendix A

Management Controls and Safe Working Procedure

Carbon Dioxide (CO₂), and Mixed Gas (a mixture of CO₂ and Nitrogen (N₂)), is supplied in cylinders containing the gas partly as liquid and partly as gas under pressure. The cylinders must be handled with care, in accordance with the Manual Handling Regulations, and should be stored safely when not in use – ie horizontal and wedged or upright and secured. They are best stored in a ventilated area, away from water, away from heat sources (including direct sunlight) and away from members of the public.

All cylinders must be secured in an upright position when in use, and must be connected to the pressure system via a pressure regulating valve. They must not be connected directly to the beer containers, and the cylinder valve should not be used as a means of controlling the flow of gas.

Gas cylinders should never be connected to unauthorised equipment and the settings on the regulating valve should never be altered or adjusted.

The cylinder valve should always be shut off when disconnecting any container from the ring main, and extractors must never be unscrewed from the beer containers.

Any staff should always be informed when anyone is about to undertake cellar work, and the BBPA safety precautions on the dispense gases poster should be followed. The cellar door should be left open when entering the cellar – to facilitate air circulation.

Remember gas cylinders can be dangerous if not handled correctly

The symptoms of inhaling CO₂ are shortness of breath, increased breathing rate, an increase of heart beat and possibly a desire to cough. Prolonged exposure after the onset of these symptoms, may lead to unconsciousness and death. All persons entering CO₂ storage areas could be exposed (eg staff, contractors). Refer to appendix B for examples of the symptoms at varying concentrations of CO₂.

If you experience shortness of breath, increased breathing rate, increased heartbeat or a desire to cough, LEAVE THE AREA AT ONCE.

If anyone has collapsed in the area ring the emergency services immediately. Ensure personnel are kept out of the area, and if doors and windows can be opened without entering the suspect area this should be done to allow increased air flow. Switch on cooling fans to help dissipation, if this can be achieved without entering the area.

Contact your gas supplier, pressure system owner, brewery or other nominated competent person for further advice or remedial action. The emergency services should be called when necessary.

Major CO₂ leaks may also be reportable to the local Environmental Health Department as a Dangerous Occurrence under RIDDOR (accident reporting regulations).

Training staff in the action to take in the event of an emergency is essential. All relevant staff should be trained in the proper storage and use of CO2 and other gases and equipment. They should be made aware of the typical effects of CO2 inhalation and advised what to do if they experience symptoms.

All employees, particularly new starters, visitors and contractors should be made fully aware of health and safety procedures.

The situation should be regularly monitored and reviewed, particularly during refurbishment or when additional equipment is installed. All gas detection equipment will require routine maintenance and recalibration.
Appendix B
Specimen Decision Tree

Largest Gas Cylinder Size:
14lbs (6.3kg) over and under 14lbs (6.3kg)

Cellar Size:
Over 3,800ft³ (110m³) Under 3,800ft³ (110m³)

Cellar:
Above Ground Below ground

Slight Risk
- Adopt safe system of work
- Monitor and review

Medium Risk
- Adopt safe system of work
- Monitor and review
- Re-assess when any alterations made

Significant Risk
- Adopt safe system of work
- Monitor and review
- Seek advice from competent person to complete detailed risk assessment
### Appendix C

Symptoms of CO$_2$ exposure at varying concentrations

<table>
<thead>
<tr>
<th>CO$_2$ concentration by volume of air</th>
<th>Effects and Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>Slight and unnoticeable increase in breathing rate</td>
</tr>
<tr>
<td>2%</td>
<td>Breathing rate increases (increase to 1.5 times normal rate), and prolonged exposure over several hours may cause headache and feeling of exhaustion</td>
</tr>
<tr>
<td>3%</td>
<td>Breathing becomes deeper (increase to twice normal rate). Hearing ability reduced, headache experienced with increase in blood pressure and pulse rate</td>
</tr>
<tr>
<td>4%-5%</td>
<td>Breathing becomes deeper and more rapid (increase to four times normal rate). Signs of intoxication after exposure for half an hour, with slight choking feeling.</td>
</tr>
<tr>
<td>5%-10%</td>
<td>Characteristic pungent odour noticeable. Breathing very laboured leading to physical exhaustion. Headache, visual disturbance, ringing in the ears and confusion, probably leading to loss of consciousness within minutes</td>
</tr>
<tr>
<td>10%-100%</td>
<td>Loss of consciousness more rapid, with risk of death from respiratory failure. Hazard to life increases with the percentage concentration, even if there is no oxygen depletion.</td>
</tr>
</tbody>
</table>
Appendix D

Measurement of the relevant areas

The beer cellar or CO₂ storage areas should be measured to obtain the approximate length, width and height. Rooms of an irregular shape should be measured in parts and the volume of each part added together to obtain an overall volume of air. The minimum air volumes used in the tables contain an additional element for fixed equipment and stock in the cellar, so no amendments are necessary in this calculation.

To calculate the volumes multiply the length by the width by the height, but keep measurements constant – either feet or metres – never mix together.
Where the beer cellar, or CO₂ storage area, permits circulation of air between adjacent rooms – utilising air bricks or grilles in doors and/or walls - those adjacent rooms should be included in the overall calculation of air volume.

Measurements should err on the side of caution where it is difficult to accurately calculate the air volume due to the irregular shape of the room. Particular care must be taken where cellar floors are sloping or contain areas at a lower level, eg. down steps. CO₂ will accumulate in these lower areas and may mean the risk is significant in a cellar that otherwise would appear to be of only slight or medium risk.

Example

A below ground beer cellar with an adjoining bottle store and cellar drop area. Largest CO₂ cylinder is 14lb (6.3kg). Two CO₂ and two Mixed Gas cylinders are in use, but not manifolded together. Four additional cylinders are stored in the cellar.

Cellar = 33ft (10m) long by 25ft (7.6m) wide by 8ft (2.5m) high = 6,600ft³ (190m³)
Bottle Store = 33ft (10m) long by 15ft (4.6m) wide by 8ft (2.5m) high = 3,960ft³ (115m³)
Total Air Volume = 10,560ft³ (305m³)

The cellar volume is already larger than required at the first risk assessment level of 3,800ft³ (110m³), and the addition of the bottle store will increase the available volume even further, providing suitable air bricks/grills are installed to allow dispersion between the two areas. This does not present a reasonably foreseeable specified risk.