POOL WATER TREATMENT
ADVISORY GROUP

TECHNICAL NOTE

6 – Carbon dioxide for pH control

August 2011
Sodium and calcium hypochlorite both tend to raise the pH of swimming pool water. So an acid is required to lower the pH value to what is best for effective disinfection – 7.2-7.4. The bottom of this range is better, bearing in mind that each extra 0.5 in pH value doubles the amount of disinfectant needed. Flocculents also work better at the lower pH values.

Sodium bisulphate and hydrochloric acid are the chemicals most often used. Carbon dioxide is an alternative well worth considering. It is not suitable for pools where the source water is high in alkalinity (over 150mg/l as $CaCO_3$) or calcium hardness (over 300mg/l as $CaCO_3$) Nor is it suitable in leisure pools and spas, where water features will drive it out of the water.
But for the majority of pools, PWTAG recommends that it should be the preferred choice.

Advantages
CO_2 offers a number of advantages over the mineral acids, sodium bisulphate and hydrochloric acid.

- CO_2 is a colourless, odourless, non-flammable gas. It is easy to handle and dose, and is dangerous only if released in a confined area, when it can asphyxiate. It requires no special protective equipment.
- Under COSHH regulations a pool operator must carry out a risk assessment in selecting the chemicals to use in a pool. The first step is to ascertain whether using an alternative process or chemical can eliminate a chemical risk: CO_2 scores on this count
- Deliveries are unlikely to result in emergencies because of spillages, and where ventilation is good, CO2 does not demand any special safety monitoring for leakage.
- Unlike mineral acids, it is not possible to mix CO2 with sodium or calcium hypochlorite (in liquid form) through spillage in bunds or operator error when acids are mixed in day or main tanks with hypochlorite. This means no possibility of accidental production of chlorine gas – a significant hazard in swimming pool installations.
- Due to its natural buffering action, CO2 provides improved process control. pH reduction is more gradual than with mineral acids, making accurate control inherently easier, but sometimes slower. CO_2 as a saturated solution has a pH of 5 while hydrochloric acid at 30% w/w has a pH of less than 1. Swimming pool water does not respond well to the sudden impact of chemicals. Some of the reactions taking place in pool water can take many hours, sometimes days, to complete. Gentle, gradual adjustment of chemicals is best practice.
- There is no secondary pollution introduced into the treated water by salts such as chlorides (from hydrochloric acid) or sulphates (from(sodium bisulphate). The introduction of CO_2 will contribute to the chemical equilibrium of water by forming carbonates and bicarbonates – contributing to total dissolved solids levels, but not to corrosion.

Additional benefits of O_2
A study published in the scientific journal Chemosphere in 2010 suggested some further advantages of using CO_2. It found that its use slightly reduces the carbon footprint of a swimming pool, producing less greenhouse gas. It also found that three pools that changed from hydrochloric acid to CO_2 had lower chlorine consumption, lower levels of oxidants in the air above the swimming pool and of trihalomethanes in the pool water. Further research is needed to determine if the buffer effect of CO_2 is the main factor in this.

Cost
CO_2 is likely to be more expensive in terms of materials. But there are hidden costs to consider. A mineral acid dosing system is likely to require more staff time for the dosing procedures. There is special personal protection clothing required. There are the costs associated with maintenance. So there may be little to choose between the two. In any case, a 25m pool is unlikely to cost much more than £2,000 a year for pH reduction – very little when set against safety and water quality considerations.

Installation
There are two types of carbon dioxide storage. Cylinders of 6.35 or 35kg capacity can be arranged in banks of two or four. Bulk storage involves a storage vessel normally installed and maintained by the CO_2 supplier. Deliveries are made from a tanker vehicle designed solely for the transport of CO_2.

The chemical is in the liquid phase in the storage container and changes to the gas phase when passed through a pressure reduction valve.

Carbon dioxide gas is denser than air, so in the event of leakage a high concentration could form in the storage area. CO_2 cylinders must be stored in a cool area with adequate low-level ventilation to the exterior of the building. If cylinders are stored in an enclosed area (particularly below ground level), with the possibility of high concentrations of CO_2 accumulating in the event of a leakage, there must be fixed CO_2 detectors or adequate mechanical ventilation. Self-contained breathing apparatus must also be made available for emergency use at the entrance and to the area. The apparatus should be of a minimum 30-min endurance and a regular system of inspection must be maintained. Personnel who might be required to use the apparatus must be trained on a regular and continuing basis.

Storage in direct sunlight or near steam pipes, radiators or other sources of heat must be avoided. The temperature of a cylinder and its contents may not always correspond to ambient temperatures. There can be considerable increase of temperature and pressure due to radiation from exposure to the sun or other sources.

The point of injection is best determined in consultation with the CO_2 supplier. To prevent scaling, the point of application is usually after the heat exchanger, with diffuser holes facing downstream.

The rate of application can be controlled automatically so that the pH of the water is maintained at a constant pre-set level.

The alternatives
The use of sodium bisulphate to lower pH will inevitably raise the sulphate level in the pool water. If it goes above the ideal maximum of 360mg/l, then sulphate-resistant cement materials will be needed. The only remedy for excessive sulphate level is dilution; the recommended guideline of 30 litres per bather may suffice.

Hydrochloric acid also poses difficulties in manual handling: ideally it should be used only at low concentrations. Bulk industrial grade can be 30 to 35% and at this level can present handling difficulties and so ideally should be diluted. Typically the concentrate is drawn into a water-operated venturi or injector that discharges into the day tank. Such dilutions are not highly accurate, but it removes the need for manual handling of strong acid. The acid actively fumes, so an open container is a hazard even without spillage.

Indeed, whenever fuming acid is held in a day tank or other container, there must be special provision (good seals etc) to prevent the fumes escaping into the atmosphere. Fumes are a threat to the fabric of the building as well as people's health.

Alternatively, hydrochloric acid can be purchased at 5% v/v strength for use in health suites, hydrotherapy and school pools. There is no fuming and far fewer handling issues. The quantities required for public pools may present a storage problem.

The use of sulphuric acid – not recommended by PWTAG – is the subject of a separate technical note on **pwtag.org.uk**.

The future
Suppliers are considering – and in some cases already installing – systems that eliminate any involvement of pool staff with the ordering, supply, delivery and application of CO_2. The suppliers contract to handle all these element. There are also moves to consolidate all the CO_2 on a sport and recreation site into one centralised system. This could provide a central CO_2 supply for all pool pH reduction, with CO_2 used in conditioning drinks in bars and where CO_2 is used in a café for delivering soft drinks.