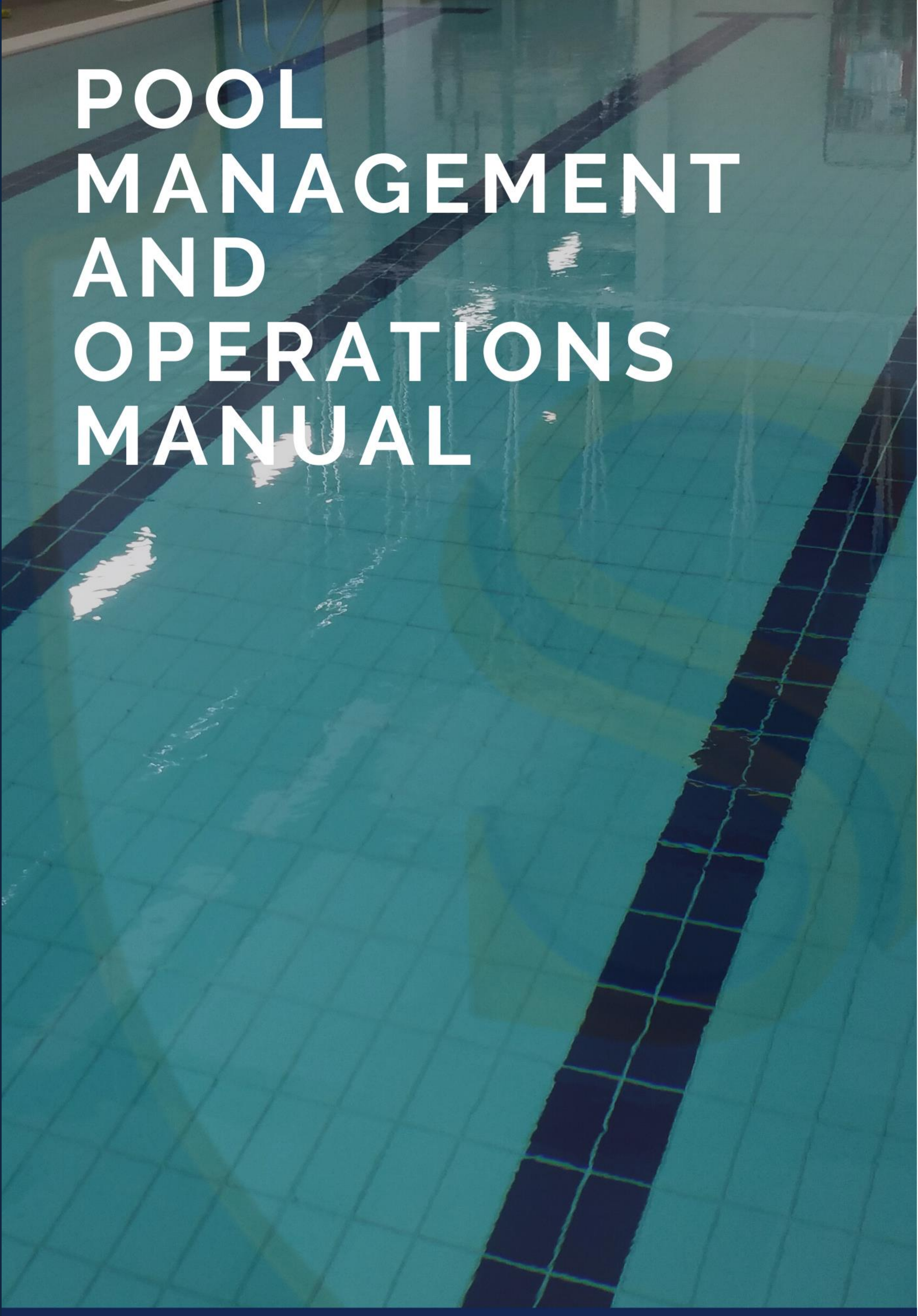
POOL MANAGEMENT AND OPERATIONS MANUAL



STOCKWELL SAFETY

Version 2.0

Contents

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01. Introduction to Swimming Pools

On completion of this lesson, you'll have a basic understanding of how pools are constructed and you'll be aware of the main risks involved in the use and operation of swimming pools. You'll also be provided with check sheets detailing water testing parameters and frequencies and all the checks that are recommended for different types of pool.

Types, Ownership and Construction of Pools

Origin and types of pool

Although the practice of bathing in man-made pools has been taking place for centuries, it was the industrial revolution that saw the introduction of swimming pools of the type we are most familiar with today. The transition from cottage industry to large-scale manufacturing created a demand for publicly accessible places to wash and bathe.

The earliest pools that were built to meet this demand were 'fill-and-empty' pools, meaning that there was no circulation, filtration or chemical treatment of the water. The pools were bathed in until such time as the water became too unhygienic for further use, then they were drained and refilled.

As early as 1837, six indoor pools with diving boards existed in London, England. The Maidstone Swimming Club in Maidstone, Kent is believed to be the oldest surviving swimming club in Britain. It was formed in 1844, in response to concerns over drownings in the River Medway, especially since would-be rescuers would often drown because they themselves could not swim to safety.

Since then, the provision of swimming facilities has continued, with many types of organisations providing them, some examples:

- Local authorities
- Schools
- Private pool owner(s)
- Leisure trusts
- Facility management companies
- Holiday parks
- NHS
- Football clubs

Public swimming pools are unusually demanding buildings that require considerable investment to design, build and operate. In addition, they must work continuously, often 24hrs a day over 365 days a year, under stringent health and safety requirements to ensure safe, supervised use.

They have high energy needs in operation and must be carefully designed to conserve energy. They contain aggressive chemicals in moisture-laden atmospheres that require careful design and high-quality materials, plant and equipment and well-qualified staff.

There are four basic types of pool construction:

- A reinforced concrete shell finished with tiles, marblite or special paint
- A blockwork or prefabricated panel shell supporting a tailor-made PVC liner
- A glass fibre or one-piece ceramic shell
- An above-ground pool

Managing design problems

While good design will eliminate many potential hazards in a new pool, you may have responsibility for an existing pool, where you cannot make changes to its layout or major features. The risk assessment process can be used to identify any physical or procedural changes or management measures to enable the pool to be used safely.

Risk Factors

Poorly maintained facilities are one of the most common causes of swimming pool accidents Examples include:

- Defective pool drainage systems
- Defective water filtration systems
- Excessive chemical content
- Damaged tiles
- Badly signposted pool depths

This list is by no means exhaustive, but it does give you an idea of the issues many people face when using swimming pool facilities. Some of the other main risk factors are covered below.

Contaminated Pool Water

Contaminated water in swimming pools can be a major problem because while there are various chemicals to counteract this issue, the constant introduction of new bodies and new substances can offer a potentially dangerous window of opportunity for contaminants to spread. Chlorine and other chemical disinfectants are used to combat this issue, but bacteria and contaminants can reach dangerous levels on occasions.

Chemical Poisoning/Burns

Those operating swimming pool facilities should be well aware of the amount of chlorine (and other chemicals) required to ensure relatively clean water and the safety of swimmers. However, there may be occasions where a miscalculation or an unexpected spillage can introduce dangerously high chemicals into a pool. This can result in chemical burns and chlorine poisoning, generally relatively mild but will obviously depend upon the substances present.

The handling of chemicals poses additional risks, especially where it could impact members of the public and children. Therefore, there should be thorough and robust procedures to control these risks; otherwise, accidents like those involved in the case studies are likely.

Drain Suction Accidents

The water is drained, filtered, and recycled to ensure that a swimming pool is as clean as possible. These relatively strong drain suction facilities are protected by an array of covers that, when fitted correctly, ensure swimmers can safely pass over them. However, there have been instances of loose drain suction covers which have resulted in severe internal and rectal injuries. These sudden injuries can disorientate an individual and potentially lead to drowning.

Confined Spaces

Cleaning or maintenance activities may require employees or contractors to enter confined spaces. A confined space is a place which is substantially enclosed (for example, a pool balance tank after it is emptied) and where serious injury can occur from hazardous substances or conditions within the space (for example, lack of oxygen).

If work is required on plant or equipment in confined spaces, pool operators must have arrangements to ensure the work can be done safely. The following principles apply: avoid working in a confined space whenever possible, for example, by doing the work outside; follow a safe system of work if working inside; make appropriate arrangements for rescue in an emergency.

Pool Water Testing Parameters and Frequencies

<table>
<tr><th>Test</th><th>Recommended Range</th><th>Recommended Frequency</th><th>Action if Too High</th><th>Action if Too Low</th></tr>
<tr><td>Free Chlorine
Subject to satisfactory microbiological quality being achieved and maintained</td><td>Pools using hypochlorites:
If pH 7.0 - 7.2: 0.75 - 1.0 mg/l
If pH 7.2 - 7.4: 2.0 mg/l
Pools using stabilised chlorine: 5.0 mg/l
Spa's: 3.0 - 5.0 mg/l</td><td rowspan="4">See ‘Recommended Checks’.</td><td>Dilute, or add sodium thiosulphate (5g per 1g of excess chlorine)</td><td>Cease bathing, add more disinfectant</td></tr>
<tr><td>Combined Chlorine</td><td>As low as possible, < 1.00 mg/l
or
< 50% of free chlorine
whichever is lowest.
The above indicates ‘breakpoint chlorination’ *</td><td>Dilute, review pre-swim showering, reduce bathing load, backwash filters</td><td>Not applicable – try and get it as low as possible</td></tr>
<tr><td>Total Bromine</td><td>4.0 - 6.0 mg/l</td><td>Dilute, or add sodium thiosulphate (5g per gram of excess chlorine)</td><td>Cease bathing, add more disinfectant</td></tr>
<tr><td>pH</td><td>Pools: 7.0 - 7.4
Spa's: 7.0 - 7.6</td><td>Add an acid (eg. Sodium bisulphate)</td><td>Cease bathing, add an alkali (eg. Sodium carbonate)</td></tr>
<tr><td>Total Dissolved Solids (TDS)</td><td><1000 ppm above source TDS</td><td>Daily</td><td>Dilute</td><td>Not applicable – try and get it as low as possible</td></tr>
<tr><td>Total Alkalinity</td><td>80 - 200 mg/l</td><td>Weekly</td><td>Dilute</td><td>Add sodium bicarbonate</td></tr>
<tr><td>Calcium Hardness</td><td>80 - 200 mg/l</td><td>Weekly</td><td>Dilute</td><td>Add calcium chloride</td></tr>
<tr><td>Water Balance (langelier index)</td><td>+/- 0.5</td><td>Weekly</td><td colspan="2">Depends – various factors may need correction</td></tr>
<tr><td>Cyanuric Acid</td><td>50 - 100 mg/l</td><td>Weekly</td><td>Dilute</td><td>Add cyanuric acid</td></tr>
</table>

Note: Pool test records should be retained for a period of 5 years.

*** Breakpoint chlorination** – A disinfection method in which chlorine dose is sufficient to oxidise rapidly all the ammonia nitrogen in the water, and to leave a suitable free chlorine residual to protect against cross-infection in the pool. When the combined chlorine level in the pool falls, after rising as chlorine is added, this indicates that nitrogenous pollution is being successfully oxidised.

Recommended Checks

	Swimming Pools	Spa Pools	Hydrotherapy Pools	Hot Tubs
Check water clarity before first use	Daily	Daily at opening and every two hours thereafter [2]	Daily	At least twice daily depending on risk assessment and usage [2]
Check automatic dosing systems are operating (including ozone or UV lamp if fitted)	Daily	Daily [2] Before opening the pool	Daily	Daily [2]
Readouts from the controller checked against the results from manual tests of the sample cell.	Daily [1]	Daily [1]	Daily [1]	-
Check that the amounts of dosing chemicals in the reservoirs are adequate	Daily	Daily [2] Before opening the pool	Daily	Daily where appropriate [2]
Determine pH value and residual disinfectant concentration	Daily [1] At least 3 times per day	Daily [2] Before opening the pool, and then every 2 hours	Daily Before the pool opens, every two hours while it is open and	At least twice daily depending on risk assessment and usage [2]

(automatically controlled systems)			then after it closes.	
Determine pH value and residual disinfectant concentration **(non-automatic systems)**	Daily [1] Before the pool opens, every two hours while it is open and then after it closes.	Daily [1] Before the pool opens, every two hours while it is open and then after it closes.	Daily [1] Before the pool opens, every two hours while it is open and then after it closes.	Daily [1] Before the pool opens, every two hours while it is open and then after it closes.
Determine combined chlorine concentration	Depending on risk assessment and usage	Depending on risk assessment and usage	Depending on risk assessment and usage	Depending on risk assessment and usage
TDS check	Weekly [1]	Daily [2]	Weekly	-
Clean water-line, overflow channels and grills	At least monthly [3]	Daily [2] At the end of the day after closing the pool	At last weekly [3]	Check daily and clean as appropriate but as a minimum at water replacement [2]
Clean pool surround	Daily [1]	Daily [2] At the end of the day after closing the pool	Daily	Check daily and clean as appropriate but as a minimum at water replacement [2]
Backwash sand filter	According to filter manufacturer guidelines, or pressure gauge readings [3] At least weekly [3]	Daily [2, 3] At the end of the day after closing the pool [2]	According to filter manufacturer guidelines, or pressure gauge readings [3] At least weekly [3]	-
Check, clean, disinfect and dry filter cartridge	-	-	-	Between each group of users or weekly, whichever is shorter [2]

Inspect strainers, clean and remove all debris if needed	Every backwash	Daily [2] At the end of the day after closing the pool	Every backwash	At water replacement [2]
Record any untoward incidents	Daily	Daily [2] At the end of the day after closing the pool	Daily	As appropriate [2]
Drain spa pool, clean whole system including strainers and refill	-	Daily to weekly based on risk assessment [2]	-	Between each group of users or at least weekly, whichever is shorter [2]
Drain and clean balance tank	Inspected once per year and cleaned as necessary [3]	At least twice per year based on risk assessment and weekly visual checks [2, 3]	Inspected once per year and cleaned as necessary	-
Microbiological tests (colony count, coliforms, E coli, P aeruginosa)	Monthly [1]	Monthly [2]	Weekly [1]	Monthly [2]
Microbiological tests (legionella)	Not normally required unless risk assessment indicates a problem	Quarterly [2, 3]	Quarterly [3]	Quarterly [2]
Remove and inspect accessible pipework and jets for presence of biofilm; clean as necessary	-	Weekly [2]	-	Weekly [2]

Disinfect flexible hoses	-	Monthly [2]	-	Monthly [2]
Clean input air filter	-	Monthly [2]	-	Monthly [2]
Check all automatic systems are operating correctly e.g. safety cut-outs, automatic timers etc.	-	Daily [2]	-	Daily, where fitted [2]
Disinfectant/pH controller _ clean electrode and check calibration	Monthly or according to manufacturers' instructions	Monthly or according to manufacturers' instructions [2]	Monthly or according to manufacturers' instructions	Monthly, where fitted, or according to manufacturers' instructions [2]
Check sand filter and effectiveness of filtration	Annual check and sand replacement every 5 – 10 years [3]	Quarterly check and annual sand replacement [2]		-
Clean and disinfect airlines	-	Quarterly [2]	-	Weekly where appropriate [2]

1) PWTAG Code of Practice
2) HSG282 The Control of Legionella and Other Infectious Agents in Spa-Pool Systems
3) Swimming Pool Water, Treatment and Quality Standards for Pools and Spas (PWTAG)

Knowledge Test (check answers with tutor)

The ______ process can be used to identify any physical or procedural changes or management measures to enable the pool to be used safely.

The suction generated at the pool drains/outlets can be fatal.

- ○ True
- ○ False

02. Pollution and Hygiene

On completion of this lesson, you'll know about all the different types of pollution that can affect pools and how to deal with them effectively. You'll know how to prevent many of these types of pollution in the first place and how to monitor a pool for microbiological contamination.

Sources of Pollution

Physical pollution

Physical pollution consists of contaminants that do not dissolve in the water (e.g., dirt, grit, sand, plasters, bits of float).

Lighter physical pollution will float on the surface of the water, where it can be removed via netting, scooping and/or skimming.

Heavier physical pollution will sink to the bottom of the pool. It can be removed either by sweeping it towards the pool outlets or vacuuming the bottom of the pool (either manually or with an automated pool vac).

Any smaller physical pollution that gets past the defences mentioned above will be transported via the circulation system to the plant room, which will be removed via the filtration system.

Chemical pollution

Chemical pollution refers to all dissolved or suspended chemicals in the swimming pool water. Different chemicals are introduced, either deliberately as part of the treatment regime or incidentally due to the nature of the source water or via transfer from bathers' bodies. Some examples:

- Cosmetics (e.g. de-odorants etc.)
- Urine
- Sweat
- Mucus

Much of the chemical pollution is caused by adding treatment chemicals (chlorine, pH correctant etc.). The rate of addition of these chemicals is often directly proportional to the addition of chemical (and other) pollution introduced by bathers. The key message here is that the importance of embedding a culture of pre-swim showering cannot be underestimated.

Source water

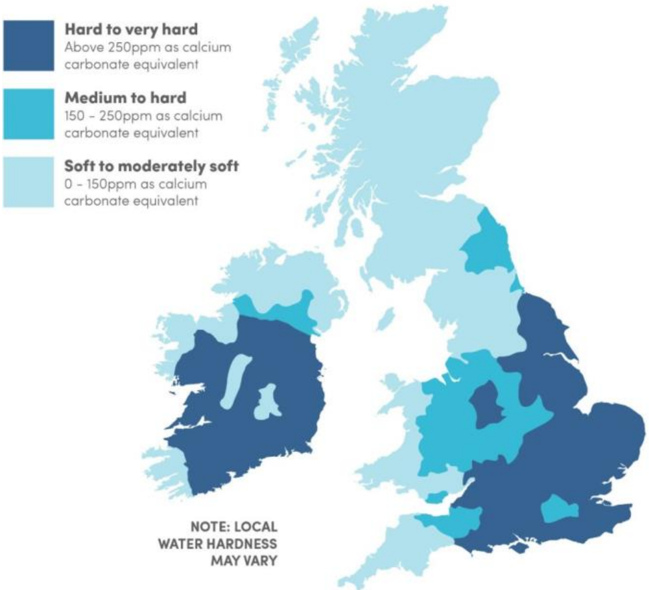
There can be several different sources of water to fill swimming pools, such as boreholes, wells, springs, lakes, reservoirs, lakes.

Water can be supplied to a location by water companies or abstracted locally under a license from the Environment Agency.

The chemical content of source water can vary according to where it comes from and how it's treated. Records are kept by water suppliers and pool operators should use the information as a key input into the pool water treatment regime.

Calcium hardness

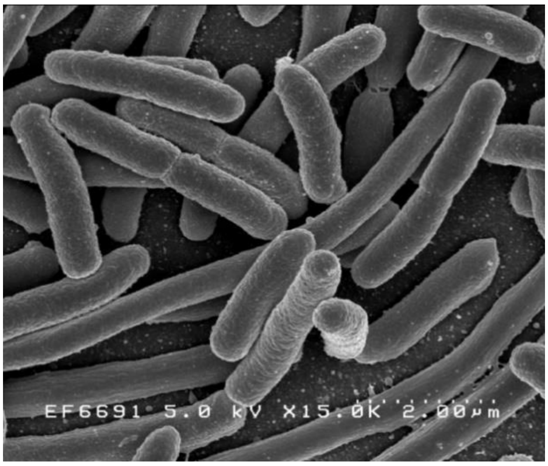
In areas with a hard water supply, water treatment chemicals mustn't further enhance the calcium hardness. For example, use sodium hypochlorite rather than calcium hypochlorite as the chlorine donor (treatment chemicals are covered later). Ideally, calcium hardness should be maintained between ***80 and 200mg/l***.



Concentrations higher than 300mg/l may result in the deposition of scale with sudden changes in temperature and pH.

Note down what type of water you have in your area (hard or soft). Then find out what chemical you use as a chlorine donor and assess whether this is the correct choice.

Biological pollution



Biological pollution is any pollution that is 'alive'. Examples below:

- Bacteria, such as e coli, legionella pneumophila, pseudomonas aeruginosa
- Protozoa, such as cryptosporidia
- Viruses
- Fungi
- Algae

Biological pollution is particularly hazardous to bathers as it can cause many infectious diseases, some of which can be fatal. It is introduced into the swimming pool water in several ways. Here are a few examples…

- On bathers' bodies (skin)
- Faecal matter
- Blood
- Mucus
- Via the source water
- On the bottom of outdoor footwear
- Canoes/scuba gear which has not been cleaned

Biological pollution needs to be dealt with via a process of disinfection. For example, the most common way of disinfecting swimming pool water in the UK is by adding a chlorine-based disinfectant to the pool water circulation system. Chlorine kills most (but not all) types of biological pollution.

Infectious Agents

Acanthameoba

Amoebae have been linked to spa pools and can contaminate contact lenses and cause corneal ulcers.

Adenoviruses

Viruses causing pharyngoconjunctival fever in under-chlorinated pools.

Cryptosporidium

Cryptosporidiosis is an infectious diarrhoeal disease caused by a waterborne protozoan parasite. It is a disease of humans and animals, including cattle and sheep. Cryptosporidiosis cases have been declining in the UK for many years, but there are still around 4000 recorded cases each year in England and Wales.

Coronavirus

The Coronavirus has had a huge impact on the swimming pool industry, including some changes to operational procedures and parameters. The industry's lead body, the Pool Water Treatment Advisory Group (PWTAG) are regularly producing detailed guidance in the form of technical notes, to help swimming pool and spa pool operators manage the risks. The first of these technical notes addressing the coronavirus was Guidance on temporary closure during coronavirus emergency (Technical Note 43), but there have been several more published since. Rather than duplicate the information contained in these technical notes, we would advise pool operators to access and download the relevant technical notes (they're free of charge) and incorporate the guidance into their internal procedures as appropriate.

Dermatophyte Fungi

Can cause athletes foot from contact with contaminated surfaces.

Escherichia Coli

VTEC (verotoxigenic E. coli – also known as Vero-cytotoxin producing E. coli) are a group of bacteria that cause diarrhoeal disease in humans. The disease can range from mild gastroenteritis to severe bloody diarrhoea and in some can develop in to a serious, potentially fatal illness.

VTEC is a common cause of diarrhoeal disease in the UK. It is easily spread because very few bacteria are required to cause infection. It is spread via consumption of undercooked, infected meat and meat products and via faeces-contaminated water. It can also be spread via contaminated vegetables and other ready to eat foods or via contact with contaminated soil. It can be spread via direct or indirect contact with infected animals. It can be spread from person to person by faecal-oral transmission.

Occupational exposure to VTEC may occur in those who:

- are in contact with infected animals or humans
- are in contact with materials or products from infected animals
- are in contact with contaminated water or soil

The incubation period is usually 3–4 days (can be 1–8 days). Symptoms range from mild diarrhoea to severe bloody diarrhoea with fever and stomach cramps. In rare cases VTEC can cause serious illness, including kidney damage and blood clotting disorders. In rare cases the disease can be fatal.

Anyone with severe symptoms should seek immediate medical attention. There is no specific treatment available for VTEC apart from rehydration therapy and most patients will recover within two weeks. Patients with kidney damage or blood clotting disorders will require specialist treatment in hospital.

The following control measures reduce the risk of infection:

- Good occupational hygiene practices should be followed, especially washing with warm water and soap
- Avoid swallowing water when participating in swimming activities
- A suitable disinfectant should be used

Enteroviruses

Includes poliovirus, echovirus and coxsackieviruses A and B and linked to pools with insufficient chlorination.

Giardia

Protozoa with similar characteristics to cryptosporidium.

Hepatitis A Virus

Spread via contaminated and underchlorinated water.

Legionella Pneumophilia

Legionellosis is a collective term for diseases caused by legionella bacteria including the most serious: Legionnaires' disease, as well as the similar but less serious conditions of Pontiac fever and Lochgoilhead fever. Legionnaires' disease is a potentially fatal form of pneumonia and everyone is susceptible to infection.

The risk increases with age, but some people are at higher risk, e.g.

- people over 45
- smokers and heavy drinkers
- people suffering from chronic respiratory or kidney disease
- diabetes, lung and heart disease
- anyone with an impaired immune system

Microsporidia

Small protozoa that are thought to cause diarrhoea in immunocompromised people.

Molluscum Contagiosum Virus

Poxyvirus that causes a skin rash. Caused by skin-to-skin contact, or sharing towels, rather than through the swimming pool water.

Mycobacterium Marinum

Bacteria that infects the skin. More resistant to chlorine than other bacteria.

Mycobacterium Avium

Bacteria that infects immunocompromised people, causing respiratory symptoms. Has been linked to spa pools and sometimes referred to as 'hot tub lung'.

Papilloma Virus

Causes verrucas by contact with contaminated surfaces.

Pseudomonas aeruginosa

There have been numerous outbreaks of folliculitis caused by P. aeruginosa associated with pools and hot tubs. The folliculitis presents as a red rash and involves infection of the hair follicles. Disease is related to the duration of pool immersion as well as the degree of contamination of the water, and children and young adults are most susceptible.

Shigella

Bacteria causing dysentery in badly-run swimming pools. Closely related to salmonella.

Staphylococcus Aureus/MRSA

Causes boils, abscesses and infected wounds. Can be resistant to methicillin and other antibiotics (Methicillin Resistant Staphylococcus Aureus MRSA). No evidence to suggest that ii is transmitted through use of swimming pools and therefore no justification for excluding MRSA carriers unless they have contaminated wounds.

Relative Pollution

Relative pollution refers to the amount of pollution entering a body of water relative to the amount of water. Therefore, any pool that has high pollution to water ratio will have high relative pollution.

Examples are:

- paddling pools
- splash zones
- teaching pools
- hydrotherapy pools

A pool that is 25 metres long, 12 metres wide, with an average depth of 1.5 metres will hold 450 cubic metres of water. If there are, say, 30 people in the pool, each of them will have 15 cubic metres of water each.

Contrast this situation with a spa pool. A spa will only hold about 3 - 10 cubic metres of water, depending on the type. Let's say we have a spa pool that holds 5 cubic metres and has 10 people in it. Each person now has only half of one cubic metre of water each.

Even though there are more people in the swimming pool (and therefore more total pollution), the relative pollution is higher in the spa due to the fact that as a percentage of volume, the pollution levels are higher. The spa is said to have higher relative pollution levels. Spa pools are not the only types of pool that suffer from high relative pollution. Any pool that has an unfavourable pollution to water ratio will also have high relative pollution.

Cryptosporidia

If a pool is contaminated with faeces, the pool operator must decide quickly on an appropriate course of action to prevent any possible illness in users. This is particularly important with diarrhoea, which may contain cryptosporidium (‘crypto’), a parasite that is resistant to chlorine. So it is crucial to be prepared. It is also essential to do everything possible to prevent such contamination in the first place.

Cryptosporidiosis is an infectious diarrhoeal disease caused by a waterborne protozoan parasite. It is a disease of humans and animals, including cattle and sheep. Cryptosporidiosis cases have been declining in the UK for many years, but there are still around 4000 recorded cases each year in England and Wales.

Cryptosporidium most commonly affects young children and the immunocompromised, but can affect anyone. Cryptosporidium is found in the gut of man and animals (particularly cattle and sheep). It is also found in water contaminated with faeces.

It can be transmitted via contact with infected animals, by drinking or swimming in contaminated water and by eating contaminated food, e.g. salad vegetables. It can be spread from person to person where there is poor hygiene.

Occupations where there may be a risk of occupationally acquired cryptosporidiosis include workers in outdoor leisure industries in contact with water.

The incubation period is 2–10 days (average 7 days). The main symptom is watery diarrhoea, but symptoms can also include fever, stomach cramps and vomiting. Anyone with severe symptoms should seek medical attention. There is no treatment apart from rehydration therapy and most people recover within one month.

Cryptosporidiosis is a predominantly waterborne disease with infections caused by contaminated drinking water, swimming pools, water features, natural waters, or acquired by animal and human contact and a range of other routes. Cryptosporidium is a particular problem for swimming pools and drinking water because the oocysts are resistant to chlorine based disinfectants.

Swimming pool contamination is likely to occur all year round, but outbreaks are more common in the late summer period; this may be as a result of people using swimming pools more and also linked to holiday travel. Swimming pool outbreaks result from contamination of the water with cryptosporidium oocysts, usually from young swimmers.

Swimmers need to make sure they:

- shower before swimming
- do not swim if they have diarrhoea
- try not to swallow pool water

Cryptosporidia is a parasite that is of particular concern for pool plant operators because it is not killed by chlorine. The parasites live inside a protective shell called an oocyst which protect them from the chlorine in the swimming pool or spa water. If these oocysts are ingested by swallowing contaminated water, the cryptosporidia with hatch out of the shells and reproduce, causing a gastro-intestinal illness. When the newly-created oocysts are expelled from the body via the faeces, the whole cycle starts again.

As chlorine is an ineffective defence, the pool plant operator must use other methods. The key operational defence is keeping cryptosporidium out of the swimming pool in the first place. Anyone diagnosed as having been infected with cryptosporidia should not go swimming until they are symptom-free for at least 14 days. Signage is required at reception areas as well as in the changing rooms etc. You also need to ensure the effective coagulation and filtration of the oocysts. The thing to bear in mind is that without the addition of a coagulant (such as poly-aluminium chloride) to the circulation system at the correct dosing rate, the oocysts will pass through the sand in a commercial swimming pool filter. This is because the oocysts are about 3-5 microns in diameter, whereas the gaps between the sand grains are about 10 microns in width in a ripened sand filter. The addition of a coagulant will cause the minute particles of pollution (including the cryptosporidium oocysts) to clump together to form what are known as 'flocs'. These flocs are large enough to not pass through the sand filter and end up in the swimming pool.

Ultra violet radiation and ozone disinfection have been found to eliminate cryptosporidia, but even when using these types of disinfection processes, the use of a coagulant is still recommended.

It is vital that pool plant operators keep their sand filters clean and well-maintained. This means that for swimming pools, the sand filters should be backwashed at least weekly, or according to the filter manufacturer's instructions. Spa pool filters should be backwashed every day.

Pool operators can help to prevent Cryptosporidium incidents by:

- discouraging babies under the age of six months from using public pools;
- encouraging all bathers to shower thoroughly before using a pool;
- providing good, hygienic nappy changing areas;
- discouraging anyone ill with diarrhoea (up to 14 days previously) from swimming.

If you end up with loose, runny stool in the swimming pool, you will need to assume that cryptosporidia is present and clear the pool and keep it closed for 6 turnover cycles. While you're closed down, backwash the filters, get the chlorine up at the high end of the acceptable range and get the pH at the low end of the acceptable range. Also, scrub, sweep, brush, squeegee, net, and vacuum the whole area before re-opening.

Pool operators should:

- ensure that filters are operating well and with coagulation
- ensure there is sufficient water replacement (particularly in periods of high bather load)
- conduct filter backwashing after the pool has closed at night
- encourage pre-swim showering
- ensure people do not use the pool if they have had within the last 48 hours (extended to 14 days if the diarrhoea was caused by cryptosporidia infection)
- close the pool for a period equivalent to 6 turnover periods in the event of a liquid faecal release into the pool
- ensure that very young children do not enter the pool unless wearing special swim nappies, designed to retain runny faecal matter

Legionella

What is legionella?

Legionellosis is a collective term for diseases caused by legionella bacteria including the most serious: Legionnaires' disease, as well as the similar but less serious conditions of Pontiac fever and Lochgoilhead fever. Legionnaires' disease is a potentially fatal form of pneumonia and everyone is susceptible to infection.

The risk increases with age, but some people are at higher risk, e.g.

- people over 45
- smokers and heavy drinkers
- people suffering from chronic respiratory or kidney disease
- diabetes, lung and heart disease
- anyone with an impaired immune system

Risk Factors and controls

The bacterium Legionella Pneumophila and related bacteria are common in natural water sources such as rivers, lakes and reservoirs, but usually in low numbers. They may also be found in purpose-built water systems, such as cooling towers, evaporative condensers, hot and cold water systems and spa pools. If conditions are favourable, the bacteria may multiply, increasing the risks of Legionnaires ' disease, and it is therefore important to control the risks by introducing appropriate measures.

Legionella bacteria are widespread in natural water systems, e.g. rivers and ponds. However, the conditions are rarely conducive for people to catch the disease from these sources. Outbreaks of the illness occur from exposure to legionella growing in purpose-built systems where water is maintained at a temperature high enough to encourage growth, e.g. cooling towers, evaporative condensers, hot and cold water systems and spa pools used in all sorts of premises (work and domestic).

Legionnaires' disease is normally contracted by inhaling small droplets of water (aerosols), suspended in the air, containing the bacteria. Certain conditions increase the risk from legionella if:

- The water temperature in all or some parts of the system may be between 20–45 °C, which is suitable for growth
- It is possible for water droplets to be produced and if so, they can be dispersed
- Water is stored and/or re-circulated
- There are deposits that can support bacterial growth, such as rust, sludge, scale, organic matter and biofilms

It is important to control the risks by introducing measures which do not allow proliferation of the organisms in the water systems and reduce, so far as is reasonably practicable, exposure to water droplets and aerosol. This will reduce the possibility of creating conditions in which the risk from exposure to legionella bacteria is increased.

Identification and assessment of the risk

Before any formal health and safety management system for water systems is implemented, the duty holder should carry out a risk assessment to identify the possible risks. The purpose of the assessment is to enable a decision on:

- the risk to health, i.e. whether the potential for harm to health from exposure is reasonably foreseeable, unless adequate precautionary measures are taken;
- the necessary measures to prevent, or adequately control, the risk from exposure to legionella bacteria

The risk assessment also enables the duty holder to show they have considered all the relevant factors, and the steps needed to prevent or control the risk.

The duty holder may need access to competent help and advice when carrying out the risk assessment. This source of advice may not necessarily be from within the person’s organisation but may be from a consultancy, water treatment company or a person experienced in carrying out risk assessments. Employers are required to consult employees or their representatives about the arrangements for getting competent help and advice.

The duty holder under, with the help of the appointed responsible person, make reasonable enquiries to ensure that organisations such as water treatment companies or consultants, and staff from the occupier’s organisation, are competent and suitably trained and have the necessary equipment to carry out their duties in the written scheme safely and adequately.

Few workplaces stay the same, so it makes sense to review regularly what you are doing.

Carrying out a risk assessment

Consider the individual nature of the site and system as a whole, including dead-legs and parts of the system used intermittently. These should be included because they can create particular problems, as microbial growth can go unnoticed. When they are brought back online, they can cause heavy contamination, which could disrupt the efficacy of the water treatment regime.

A schematic diagram is an important tool to show the layout of the plant or system, including parts temporarily out of use and should be made available to inform the risk assessment process. These are not formal technical drawings and are intended to be easy to read without specialised training or experience. While providing only an indication of the size and scale, they allow someone unfamiliar with the layout of a system to understand the relative positions and connections of the relevant components quickly. They also help the person who carries out the assessment decide which parts of the water system, e.g. which specific equipment and services, may pose a risk to those at work or other people.

There are a number of factors that create a risk of someone acquiring legionellosis, such as:

- the presence of legionella bacteria
- conditions suitable for growth of the organisms, e.g. suitable water temperature (20 °C–45 °C) and deposits that are a source of nutrients for the organism, such as sludge, scale, rust, algae, other organic matter and biofilms
- a means of creating and spreading breathable droplets, e.g. the aerosol generated by cooling towers, showers or spa pools
- the presence (and numbers) of people who may be exposed, especially in premises where occupants are particularly vulnerable, e.g. healthcare, residential and nursing homes

The following list contains some of the factors to consider, as appropriate, when carrying out the risk assessment:

- the source of system supply water, e.g. whether from a mains supply or not;
- possible sources of contamination of the supply water in the premises before it reaches the cold water storage tank, calorifier, cooling tower or any other system using water that may present a risk of exposure to legionella bacteria;
- the normal plant operating characteristics
- unusual, but reasonably foreseeable operating conditions, e.g. breakdowns
- any means of disinfection in use
- the review of any current control measures
- the local environment

Where there are five or more employees, the significant findings of the assessment must be recorded but in any case, it may be necessary to record sufficient details of the assessment to be able to show that it has been done. Link the record of the assessment to other relevant health and safety records and, in particular, the written legionella control scheme.

Employers must consult employees or their representatives on the identified risks of exposure to legionella bacteria and the measures and actions taken to control the risks. Employees should be given an opportunity to comment on the assessment and control measures and the employer should take account of these views, so it is important for employers to publicise to employees that a legionella risk assessment has been performed. Employers may wish to involve employees and/or safety representatives when carrying out and reviewing risk assessments as a good way of helping to manage health and safety risk.

It is essential to monitor the effectiveness of the control measures and make decisions about when and how monitoring should take place.

If the risks are considered insignificant and are being properly managed to comply with the law, the assessment is complete. It may not be necessary to take any further action, but it is important to review the assessment periodically, in case anything has changed.

The record of the assessment is a living document that must be reviewed to ensure it remains up-to-date. Arrange to review the assessment regularly and specifically whenever there is reason to suspect it is no longer valid. An indication of when to review the assessment and what to consider should be recorded. This may result from, e.g.:

- changes to the water system or its use
- changes to the use of the building in which the water system is installed
- the availability of new information about risks or control measures
- the results of checks indicating that control measures are no longer effective
- changes to key personnel
- a case of legionnaires' disease/legionellosis associated with the system

Managing the risk: Management responsibilities, training, and competence

Inadequate management, lack of training and poor communication are all contributory factors in outbreaks of Legionnaires' disease. It is therefore important that the people involved in assessing risk and applying precautions are competent, trained and aware of their responsibilities.

The duty holder should specifically appoint a competent person or persons to take day-to-day responsibility for controlling any identified risk from legionella bacteria, known as the 'responsible person'. It is important for the appointed responsible person to have sufficient authority, competence and knowledge of the installation to ensure that all operational procedures are carried out effectively and in a timely way. Those specifically appointed to implement the control measures and strategies should be suitably informed, instructed and trained and their suitability assessed. They must be properly trained to a level that ensures tasks are carried out in a safe, technically competent manner; and receive regular refresher training. Keep records of all initial and refresher training. If a duty holder is self-employed or a member of a partnership, and is competent, they may appoint themselves. The appointed responsible person should have a clear understanding of their role and the overall health and safety management structure and policy in the organisation.

Competence

The duty holder should also ensure that all employees involved in work that may expose an employee or other person to legionella are given suitable and sufficient information, instruction and training. This includes information, instruction and training on the significant findings of the risk assessment and the appropriate precautions and actions they need to take to safeguard themselves and others.

This should be reviewed and updated whenever significant changes are made to the type of work carried out or methods used. Training is an essential element of an employee's capability to carry out work safely, but it is not the only factor: instructions, experience, knowledge and other personal qualities are also relevant to perform a task safely.

Implementation of the control scheme

Monitor the implementation of the written scheme for the prevention and control of the risk. Supervise everyone involved in any related operational procedure properly. Define staff responsibilities and lines of communication properly and document them clearly.

Make arrangements to ensure that appropriate staff levels are available during all hours the water system is operating. The precise requirements will depend on the nature and complexity of the water system. In some cases, e.g. where there is complex cooling plant, shift working and arrangements to cover for all absences from duty, for whatever reason, may be necessary. Appropriate arrangements should be made to ensure that the responsible person, or an authorised deputy, can be contacted at all times.

Also, make call-out arrangements for people engaged in the management of water systems which operate automatically. Details of the contact arrangements for emergency call-out personnel should be clearly displayed at access points to all automatically or remotely controlled water systems.

Communications and management procedures are particularly important where several people are responsible for different aspects of the operational procedures. For example, responsibility for applying control measures may change when shift work is involved, or when the person who monitors the efficacy of a water treatment regime may not be the person who applies it. In such circumstances, responsibilities should be well defined in writing and understood by all concerned. Lines of communication should be clear, unambiguous and audited regularly to ensure they are effective. This also applies to outside companies and consultants who may be responsible for certain parts of the control regime.

Employing contractors or consultants does not absolve the duty holder of responsibility for ensuring that control procedures are carried out to the standard required to prevent the proliferation of legionella bacteria. Dutyholders should make reasonable enquiries to satisfy themselves of the competence of contractors in the area of work before they enter into contracts for the treatment, monitoring, and cleaning of the water system, and other aspects of water treatment and control. An illustration of the levels of service to expect from Service Providers can be found in the Code of Conduct administered by the Legionella Control Association (LCA).

Preventing or controlling the risk from exposure to legionella bacteria

Once the risk has been identified and assessed, a written scheme should be prepared for preventing or controlling it. In particular, the written scheme should contain the information about the water system needed to control the risk from exposure. However, if it is decided that the risks are insignificant and are being properly managed to comply with the law, you may not need to take any further action. But it is important to review the risk assessment regularly and specifically if there is reason to suspect it is no longer valid, for example changes in the water system or its use. The primary objective should be to avoid conditions that allow legionella bacteria to proliferate and to avoid creating a spray or aerosol. It may be possible to prevent the risk of exposure by, e.g., using dry cooling plant. Where this is not reasonably practicable, the risk may be controlled by minimising the release of droplets and ensuring water conditions that prevent the proliferation of legionella bacteria. This might include engineering controls, cleaning protocols and other control strategies. Make decisions about the maintenance procedures and intervals, where relevant, on equipment used for implementing the control measures.

Legionella bacteria may be present in low or very low numbers in many water systems, but careful control will prevent them from multiplying.

The written scheme should give details on how to use and carry out the various control measures and water treatment regimes, including:

- the physical treatment programme – e.g. using temperature control for hot and cold water systems
- the chemical treatment programme, including a description of the manufacturer's data on effectiveness, the concentrations and contact time required
- health and safety information for storage, handling, use and disposal of chemicals
- system control parameters (together with allowable tolerances); physical, chemical and biological parameters, together with measurement methods and sampling locations, test frequencies and procedures for maintaining consistency
- remedial measures to take in case the control limits are exceeded, including lines of communication
- cleaning and disinfection procedures
- emergency procedures

The written scheme should also describe the correct operation of the water system plant, including:

- commissioning and recommissioning procedures;
- shutdown procedures;
- checks of warning systems and diagnostic systems in case of system malfunctions;
- maintenance requirements and frequencies;
- operating cycles – including when the system plant is in use or idle

Review of control measures: Monitoring and routine inspection

The frequency and extent of routine monitoring will depend on the operating characteristics of the water system. Testing of water quality is an essential part of the treatment regime, particularly in cooling systems. It may be carried out by a service provider, such as a water treatment company or consultant, or by the operator, provided they have been trained to do so and are properly supervised. The type of tests required will depend on the nature of the water system.

The routine monitoring of general bacterial numbers (total viable count) is also appropriate as an indication of whether microbiological control is being achieved. This is generally only carried out for cooling tower systems, but it is also recommended for spa pools. The risk assessment will help identify if you need to conduct routine monitoring in the specific system. Periodic sampling and testing for the presence of legionella bacteria may also be relevant to show that adequate control is being achieved. However, reliably detecting the presence of legionella bacteria is technically difficult and requires specialist laboratory facilities. The interpretation of results is also difficult; a negative result is no guarantee that legionella bacteria are not present in the system. Conversely, a positive result may not indicate a failure of controls, as legionella are present in almost all natural water sources.

A suitably experienced and competent person should interpret the results of monitoring and testing. Carry out any remedial measures promptly, where needed.

Record keeping

To ensure that precautions continue to be applied and that adequate information is available, where there are five employees or more, you must keep a record of the assessment, the precautionary measures, and the treatments. All records should be signed, verified or authenticated by those people performing the various tasks assigned to them.

The following items should normally be recorded:

- names and positions of people responsible, and their deputies, for carrying out the various tasks under the written scheme;
- a risk assessment and a written scheme of actions and control measures;
- schematic diagrams of the water systems;
- details of precautionary measures that have been applied/implemented including enough detail to show that they were applied/implemented correctly, and the dates on which they were carried out;
- remedial work required and carried out, and the date of completion
- a log detailing visits by contractors, consultants and other personnel
- cleaning and disinfection procedures and associated reports and certificates
- results of the chemical analysis of the water;
- results of any biological monitoring
- information on other hazards, e.g. treatment chemicals;
- training records of personnel
- the name and position of the person or people who have responsibilities for implementing the written scheme, their respective responsibilities and their lines of communication;
- records showing the current state of operation of the water system, e.g. when the system or plant is in use and, if not in use, whether it is drained down
- either the signature of the person carrying out the work, or other form of authentication where appropriate.

Instantaneous and Daily Bather Loads

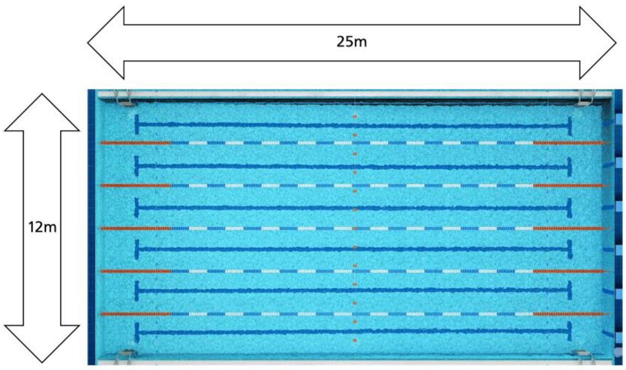
Pool operators need to establish two different types of bather load (discussed below):

1. Instantaneous bather load
2. Total daily bather load

Instantaneous bather load

The typical starting point for determining this is to allow at least 3 square metres of water surface area per pool user. But this is only a guide. The risk assessment should take other factors into account, e.g.:

- Swimming ability
- Age of swimmers
- Visibility
- Lifeguard provision



Based on the pool dimensions in the image, can you fill in the missing information?

The surface area is ______ square metres. To allow at least 3 square metres per bather, there can be no more than ______ bathers in this pool at any one time.

Check the answers with your tutor.

Turnover time

In addition to an increased risk of drowning, the more bathers in a body of water (bather load), the more pollution will be introduced and the more important it will be to get rid of the dirty water and introduce fresh water quickly.

This is achieved via circulation of the water via powerful centrifugal pumps. The time it takes to move water around the system (**turnover time**) is an important factor in maintaining good water quality. The quality of the pool water will deteriorate the longer it takes to circulate the water around the system.

Total daily bather load

In addition to ensuring an adequate turnover time, pool operators need to establish sensible limits on the maximum number of bathers that can use the pool on a daily basis.

To work this out, you take the instantaneous bathing load you have already calculated, take 25% to 50% of it and multiply by 12 (or, the number of daily opening hours).

Pool operators should only go to the upper end of the range if they are confident that the pool plant system can handle it and maintain good water quality. If in doubt, the advice would be to stay in the bottom half of the range.

Based on the instantaneous bather load calculated previously and 12 hours opening time, can you fill in the missing information? Check the answers with your tutor.

25% - 50% of the instantaneous bather load is ______ - ______ bathers.

Therefore, the daily bathing load would be anywhere between ______ - ______ bathers per day.

Microbiological testing

All non-domestic pools should be getting the pool water tested at a UKAS-accredited laboratory for microbiological contamination. In most pools this should be done on a monthly frequency, but certain pools, such as hydrotherapy pools, it should be done on a weekly basis. Whenever a microbiological sample is taken it is important that a pool water chemical test of free and combined chlorine and pH is taken at the same time as a reference. The water clarity and the bather load should also be noted.

The required tests and acceptable levels

Colony Count	This is a count of all types of bacteria that have been able to form a colony on the laboratory media under the test conditions. Sometimes this test is referred to as total viable count (TVC) or total plate count. **Acceptable level: < 10cfu/ml**
Total Coliforms	Total coliforms include bacteria that are found in the soil, in water that has been influenced by surface water, and in human or animal waste. Faecal coliforms are the group of the total coliforms that are considered to be present specifically in the gut and faeces of warm-blooded animals. The presence of total coliforms in the water may indicate that faecal or environmental contamination.

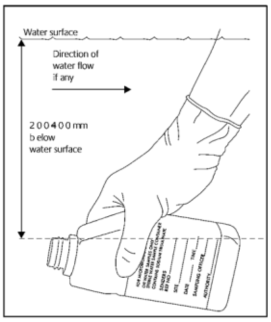
	Acceptable level: < 10cfu/100ml
E. Coli	Escherichia coli, also known as E. coli, is a Gram-negative, facultative anaerobic, rod-shaped, coliform bacterium of the genus Escherichia that is commonly found in the lower intestine of warm-blooded organisms. The presence of this bacteria in the water is an indication of faecal contamination. **Acceptable level: 0cfu/ml**
Pseudomonas Aeruginosa	These bacteria can cause folliculitis (a type of skin infection) and are widely distributed in the environment. The presence of these bacteria indicates colonisation of part of the system (probably the filters). They can be present in a sample, even in the absence of coliforms, hence their inclusion in the standard microbiological tests. **Acceptable level: < 10cfu/ml**

If you get the lab results back and any of them are outside of these ranges, you need to get the water tested again.

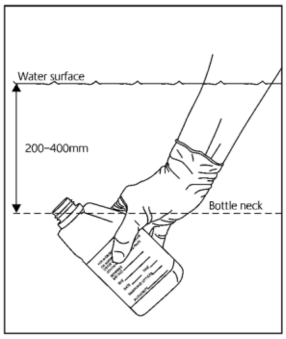
If the repeat tests are still not within the acceptable ranges, the pool operator should take this as an indication that the pool water treatment and/or management system is not functioning as it should. The system and arrangements for managing the pool water quality will need to be looked at with a view to pinpointing exactly what is wrong and then putting it right.

Correct sampling technique

1. Aseptically removing the bottle top

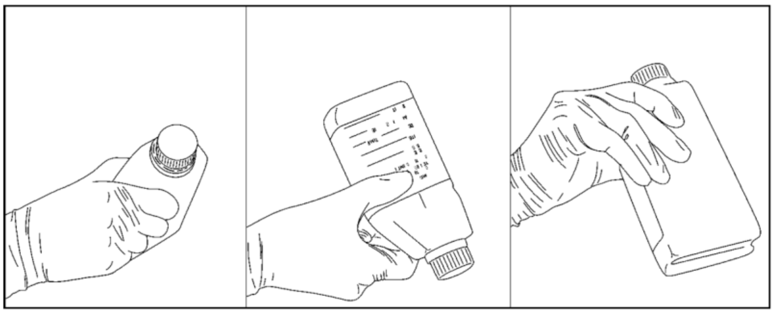


2. Immerse bottle 200–400mm below the surface, keeping bottle almost horizontal but tipped slightly to ensure neutraliser is not tipped out

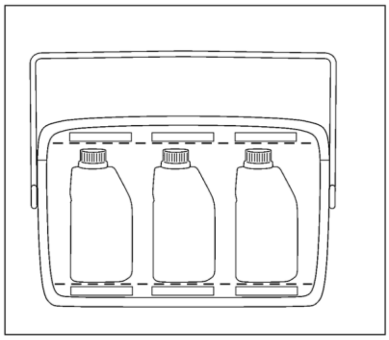


3. Tilt bottle up to approximately 45° to fill

4. Remove bottle. If the bottle is full to the brim pour off a small amount to leave 1–2cm air above the water surface. Replace the cap



5. Invert a few times to mix the contents and place the bottle in a cool box for transport



6. Transport to laboratory as soon as possible in an insulated container – process on day of collection

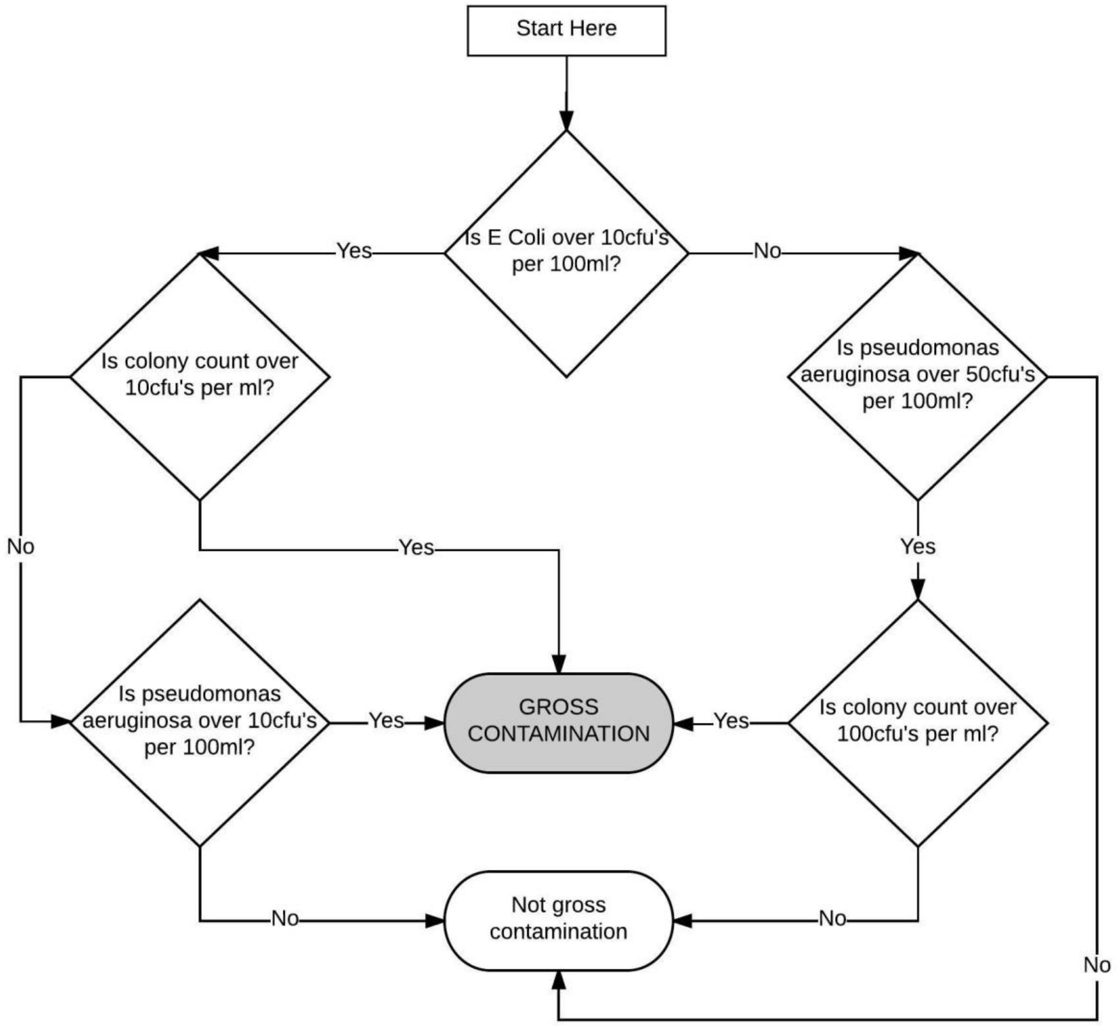
Gross Microbiological Contamination

What if the results are way outside the acceptable ranges? When does the pool operator need to close the pool due to microbiological contamination? The official guidance is that **the pool should be closed if any of the monthly microbiological test results indicate either of the following scenarios:**

- greater than 10 E. coli per 100ml in combination with an unsatisfactory colony count (>10 per ml) and/or an unsatisfactory Aeruginosa count (>10 per 100ml)

- greater than 50 Aeruginosa per 100ml in combination with a high aerobic colony count (>100 per ml)

The flow chart can help to interpret these parameters.



Here is a report from a laboratory (click to enlarge). Results are:

- Aerobic Colony Count = **1 CFU/ml**
- E. Coli = **Not Detected**
- Coliform Bacteria = **Not Detected**
- Pseudomonas Aeruginosa = **16 CFU/100ml**

Public Health England

Food, Water and Environmental Microbiology Laboratory, Preston
Royal Preston Hospital, Sharoe Green Lane
Preston, Lancashire, PR2 9HT

Tel:01772 524068 Fax: Email: LabFwePreston@phe.gov.uk

UKAS TESTING 1496

Senders Ref No. : **041/W/4752**

Lab Ref No. : **PR1622455-02**

Sample Type	: Swimming Pool Water (MF)	Sample Point	: Other - see sample details
		Sampled By	: KLH
		Purchase Order Number	:
Food Category	: Not Applicable	Date and Time of Sampling	: 20/10/2016 09:40
Sample Description	: Swimming pool water - paddling pool	Date and Time Received	: 20/10/2016 15:00
		Date and Time Examined	: 20/10/2016 15:48
		Temp at Sampling (°C)	: Not Entered
		Temp on Receipt (°C)	: 6.2
Use By/Best Before	:	Condition of Coolbox on receipt	: Satisfactory
BatchNo.	:		
Reason for Sampling	: Routine		
Country of Origin	:		
Non-PHE Survey Reference / Notes	:	Condition of sample on receipt	: Satisfactory

MICROBIOLOGICAL EXAMINATION - WATER **FINAL TEST REPORT**

Test	Method Ref.	Result	Unit	** Interpretation
Aerobic Colony Count at 37 °C for 24 hours	WM07	1	CFU/mL	Satisfactory
Escherichia coli	WM02	Not Detected	CFU in 100mL	Satisfactory
Coliform bacteria	WM02	Not Detected	CFU in 100mL	Satisfactory
Pseudomonas aeruginosa	WM09	16	CFU in 100mL	Borderline

Opinions and Interpretation

** Interpretation based on Treatment and Quality Standards for Pools and Spas. Pool Water Treatment Advisory Group. Second Edition 2009

Does the report indicate gross microbiological contamination?

What should the pool operator do in response to these results?

Discuss these questions with your tutor.

Legionella testing

Spa's

As swimming pools and hydrotherapy pools are not recognised as a source for legionnaire's disease, routine testing for legionella for these types of pools is not normally required. Spa pools, however, are a recognised source and therefore need to **get the water sampled and tested for the presence of legionella bacteria on a quarterly basis** (more frequently if there are doubts or concerns regarding the effectiveness of the pool management system). Samples should be collected from the pool and balance tank and legionella should be absent in a one litre sample. If any legionella is present, the pool should be resampled, drained, cleaned and disinfected. The pool management system should be reviewed, along with the risk assessment. The pool should be retested the day after refilling and again 2 – 4 weeks after. If the numbers of legionella detected are over 1,000 cfu's in a one litre sample, the pool should be closed and public access restricted. The pool should be superchlorinated with 50mg/l of chlorine for 16 hours (with circulation on, but air blowers off). The same steps as described above should then be carried out. The pool should not be opened again until the absence of legionella has been confirmed.

Hot & Cold Water Systems (including showers etc.)

Microbiological monitoring of domestic hot and cold water supplied from the mains is not usually required unless the risk assessment or monitoring indicates there is a problem. The risk assessment should specifically consider systems supplied from sources other than the mains, such as private water supplies, and sampling and analysis may be appropriate.

Legionella monitoring should be carried out where there is doubt about the efficacy of the control regime or it is known that recommended temperatures, disinfectant concentrations or other precautions are not being consistently achieved throughout the system. The risk assessment should also consider where it might also be appropriate to monitor in some high-risk situations, such as certain healthcare premises.

The circumstances when monitoring for legionella would be appropriate include:

- water systems treated with biocides where water is stored or distribution temperatures are reduced. Initial testing should be carried out monthly to provide early warning of loss of control. The frequency of testing should be reviewed and continued until such a time as there is confidence in the effectiveness of the regime;

- water systems where the control levels of the treatment regime, eg temperature or disinfectant concentrations, are not being consistently achieved. In addition to a thorough review of the system and treatment regimes, frequent testing, eg weekly, should be carried out to provide early warning of loss of control. Once the system is brought back under control as demonstrated by monitoring, the frequency of testing should be reviewed;
- high-risk areas or where there is a population with increased susceptibility, eg in healthcare premises including care homes;
- water systems suspected or identified in a case or outbreak of legionellosis where it is probable the Incident Control Team will require samples to be taken for analysis.

Microbiological Contamination Outbreaks

Written procedures are needed for dealing with an outbreak. They should be included in the EAP section of the PSOP. Inadequacies in the management approach taken concerning swimming pools and spas have been identified as a significant causal factor in several outbreaks in the UK.

An outbreak might be detected by pool staff or picked up by local or national surveillance and reporting systems, such as those managed by Environmental Health Departments.

An Outbreak Control Team (OCT) is typically established by the relevant authorities in an outbreak. It is headed up by a Consultant in Communicable Disease Control (CCDC). The OCT will identify the outbreak's source and direct and root causes. This might well involve site visits by members of the OCT and the collection of water samples for testing, an inspection of the pool plant system, close scrutiny of documentation, and the interviewing of key staff.

Typical problems that have led to outbreaks are listed below:

- Inadequate water disinfection
- Sewage contamination
- Inadequate filtration
- Incorrect backwash procedures
- Inadequate disinfection of pool surround and changing room floors
- Sharing of towels
- Hot and cold water system design faults
- Inadequate cleaning of showerheads
- Release of faecal matter and/or vomit into pool and/or surrounding area
- Lack of pre-swim showering
- Inadequate cleaning of pool inflatables

Public Health Wales Checklist

Public Health Wales use a checklist when investigating communicable disease outbreaks. It's geared towards cryptosporidia outbreaks, but pool operators might find it a useful resource for scrutinizing their own processes and procedures following poor microbiological test results.

Download the checklist at https://stockwellsafetylms.com/wp-content/uploads/2021/12/CRUGUID102-v4-revisions-Appendix-1-Checklist.doc.

Pre-Swim Hygiene

Consider the following facts:

- the pollution on bather bodies is what makes up most of the contamination in the pool
- the remainder of the pollution only exists in the first place because of the chemical reactions resulting from the chemicals you have to add to deal with the above.
- pre-swim showering removes most of the pollution on bathers
- less bather pollution = less chemicals = less chemical by-products = better pool water = happy bathers

How difficult would it be to ensure that every bather, without fail, showers before entering your pool? It is, after all, *your* pool and your responsibility to keep it clean and safe.
Ensure that the pre-swim showers are

- working
- warm enough
- situated on the journey from the changing rooms to the swimming pool

Similarly, with toilets, ensure that they are not unpleasant to use, are kept clean, and are conveniently situated so that swimmers are not discouraged from using them.
Control entry using notices at reception saying that people with diarrhoea must not swim – then or for 48 hours afterwards. Those diagnosed with cryptosporidiosis must not swim for 14 days after the diarrhoea has stopped.

Child and baby hygiene

Children under 6 months should not use public pools as they share the water with other swimmers (temperatures and pool water chemicals may affect sensitive skin). Ideally, young children's pools should be provided with separate water treatment and filtration. In addition, they should be able to be emptied in the event of a faecal fouling incident.
Very young children should use special swimming nappies designed to absorb and retain any soiling. Standard nappies are not adequate protection. Neither is suitable in the event of diarrhoea; in this case, babies should not use the pool.

Convenient nappy changing facilities should be provided in changing areas. These should be cleaned regularly, be equipped with sinks for hand-washing and have bins for nappy disposal emptied regularly

Dealing with Faecal, Blood, Vomit Contamination

This is a difficult area, both for pool operators and for those attempting definitive guidelines. And there is potentially a lot at stake, as diarrhoea may contain the chlorine-resistant pathogen Cryptosporidium – a significant cause of gastroenteritis, particularly in pools.

If faecal contamination has only been reported, and there is some doubt about the accuracy of the report, its presence should be confirmed by pool staff. If it cannot be confirmed, pool operators must assess the risk and may decide that the risk of harmful contamination is low and allow bathing to continue. This assumes that pH and disinfection are within normal limits. Pools should maintain a faecal accident log.

All faeces contain potentially harmful microorganisms. The actual risk to pool users depends on whether the faeces are solid or non-solid.

Solid Faeces

Solid faeces are relatively easy to deal with. It is unlikely that the perpetrator is suffering from an acute gastrointestinal illness. And the microorganisms in it are relatively contained.

1. The stools should immediately be removed from the pool using a scoop or fine mesh net and flushed down the toilet (not put in any pool drains).
2. There must be certainty that all the faeces have been captured and disposed of. If not, and there is possible widespread distribution of the faeces in the pool, then the pool should be closed and the advice below for runny faeces considered.
3. All equipment that has been used in this process should be disinfected using a 1% solution of hypochlorite.
4. If the pool is operating properly with appropriate disinfectant residuals and pH values, no further action is necessary.
5. Depending on the extent of the contamination, how public it has been, and how quickly it can be dealt with, operators should consider clearing the pool of bathers

6. for, say, 30 minutes while steps 1-4 are negotiated. This is certainly necessary if
7. the faeces has broken up. Bathing should not resume until all the faeces have
8. been removed.

Runny Faeces

Pools with high-rate filtration (over 25 and up to 50 metres per hour)

High-rate filters do not filter cryptosporidium oocysts, or anything else, as well as medium-rate filters. But because many pools have them, it is important to know how to deal with faecal contamination.

The main emphasis is on superchlorination. High-rate filters without coagulation remove as little as 10% of cryptosporidium oocysts in each pass. Even with coagulation, and perhaps 50% removal, it could take two days to be safe.

1. Close the pool – and any other pools whose water treatment is linked to the fouled pool. If people transfer to another pool, they should shower first using soap and water.
2. If coagulation is not the norm, a supply of polyelectrolyte coagulant should be available so it can be hand-dosed in these circumstances, following manufacturers' instructions.
3. Superchlorinate to 20mg/l adjusting the pH to 7.2-7.4 and leave for 13 hours (or 50mg/l for 5 hours). Procedures and supplies must be in place for this.
4. Vacuum and sweep the pool.
5. Make sure the pool treatment plant is operating as it should.
6. Backwash the filters.
7. Allow the filter media to settle by running to drain for a few minutes (rinse cycle) before reconnecting the filter to the pool.
8. Reduce the free chlorine residual to normal by dilution with fresh water or using an approved chemical. This may mean using the chemical gradually; procedures and supplies must be in place for this.
9. When the disinfectant residual and pH are at normal levels for the pool, reopen.

Superchlorination should remove any current contamination but will not guarantee future water quality. So it is important to review procedures for the control and removal of contamination by Crypto.

Pools with medium-rate filtration (up to 25 metres per hour)

This should include most public pools. Here the main emphasis is on filtration, which if effective should remove some 99% of the Cryptosporidium ocysts in each pass of pool water through the filter.

Coagulation is critical in this: it should be continuous, and the residence time (that between the injection of coagulant and treated water reaching the filter) must be long enough for flocculation to happen – at least 10 seconds at a flow velocity no more than 1.5m/ sec. Secondary disinfection (UV or ozone) and superchlorination are also relevant.

How long it takes for all the pool water to pass through the filter will depend on two factors. First is the pool hydraulics – crucially, how well mixed the pool water is. Dead spots will delay the passage of all the pool water through the filters. The second factor is the turnover period – the length of time it takes for a volume of water equivalent to the pool water volume to go from pool to plant room and round to the pool again. It might take as long as 24 hours for all the pool water to pass through the filters – based on the 3 to 4-hour turnover period common to many pools.

This, then, is the procedure.

1. Close the pool – and any other pools whose water treatment is linked to the fouled pool. If people transfer to another pool, perhaps from a teaching pool to a main or leisure pool, they should shower first using soap and water.
2. Hold the disinfectant residual at the top of its set range for the particular pool (eg 2.0mg/l free chlorine if the range is 1.0 to 2.0mg/l) and the pH value at the bottom of its range (e.g. pH 7.2-7.4). This will maintain the normal level of microbiological protection.
3. Ensure that the coagulant dose is correct – for continually dosed PAC, 0.1ml/m3 of the total flow rate.
4. Filter for six turnover cycles (which may mean closing the pool for a day). This assumes good hydraulics and well-maintained filters with a bed depth of 800mm and 16/30 sand. This applies also to pools with secondary disinfection.
5. Monitor disinfection residuals throughout this period
6. Vacuum and sweep the pool. Cleaning equipment, including automatic cleaners, should be disinfected after use. This will at least move faecal contamination off surfaces and into the main pool water circulation, for eventual removal.
7. Make sure the pool treatment plant is operating as it should (filters, circulation, disinfection)
8. After six turnovers, backwash the filters.
9. Allow the filter media to settle by running water to drain for a few minutes before reconnecting the filter to the pool.
10. 10.Circulate the water for 8 hours. This will remove any remaining oocyst contamination of the pool and allow the filters to ripen. It is optional, depending on the pool operator's confidence in backwashing procedures.
11. Check disinfection levels and pH. If they are satisfactory re-open the pool.
12. Any moveable floors and booms should be moved around from time to time during the whole process.

"How do I know if I have high or medium rate filters?"

This is covered in the 'Filtration and Coagulation chapter.

“What does ‘turnover’ mean?“

This is the amount of time it takes to circulate the pool volume around the treatment system.

“What does ‘coagulation’ mean?“

Cryptosporidia is ***not going to be killed by the chlorine in the pool***, so it is essential that it is retained within the filter, but filtration alone is not sufficient to trap very small particulate pollution. A coagulant is required, which works by causing the small particles suspended in the pool water to bind together to form what are known as flocs.

Water features

If a pool is closed for six turnovers after faecal contamination, the circulation should include any water features, which should be kept running. The same applies if superchlorination is employed.

Secondary disinfection

Secondary disinfection using UV is strongly recommended by PWTAG – partly to counter the threat from cryptosporidium and partly for its other water quality benefits, including allowing pools to operate with lower disinfectant residuals. UV plus good coagulation and filtration provides a multi-barrier defence against cryptosporidium.

All pools should do a risk assessment to determine whether secondary disinfection is required. The risk assessment should take into account the hydraulic and filter characteristics of the pool, as well as the risk from routine unseen contamination. It is particularly recommended for hydrotherapy pools and pools used by young children. Their users are likely to be more vulnerable to – and to be carriers of – Cryptosporidium.

Where used, UV should be applied to the full flow and be capable of a 3log (99.9%) reduction in viable cryptosporidium oocysts. UV installations should be medium pressure, 60mJ/cm2 and monitored to ensure an effective dose rate.

Superchlorination

The US Centers for Disease Control (CDC) recommends high chlorine concentrations alone (eg 20mg/l for 13 hours) to inactivate cryptosporidium if any swimming pool is contaminated.

In practice, many pools would find achieving and maintaining such residuals difficult with standard dosing equipment. Then there is the possibility of generating unwelcome disinfection byproducts as a result. And finally there is the challenge of reducing residual levels afterwards – either chemically or by water replacement. The effectiveness of this approach is difficult to monitor, and is no quicker than the coagulation and filtration method above. Coagulation, filtration and backwashing are certainly also needed. And any UV (or ozone) plant should be switched off and by-passed during superchlorination.

Operators may wish to consider superchlorination, either on its own or alongside PWTAG's filtration method – belt and braces. Operators should be confident that the pool plant, including valves etc, will withstand superchlorination.

Blood and Vomit Contamination

The most common infections spread in pools and spas are gastrointestinal (e.g. Cryptosporidium and viruses) and skin rashes (bacteria mainly). Blood and vomit are unlikely to cause illness because they are less likely to be infected than faeces. Skin and pool disinfectants should kill any bugs present, provided disinfectant residuals and pH values are within recommended ranges. But there are some precautions to take. See below.

Blood

Small amounts of blood, eg.: from a nose bleed, will be quickly dispersed and any germs present killed by the disinfectant in the water.

If significant amounts of blood are spilled into the pool, it should be temporarily cleared of people, to allow the pollution to disperse and any infective particles to be neutralised by the residual disinfectant.

Operators should confirm that disinfectant residuals and pH values are within the recommended ranges; bathing can then resume.

Any blood spillages on the poolside should not be washed into the pool or poolside drains and channels. Instead, like blood spillage anywhere in the building, it should be dealt with using strong disinfectant – of a concentration equivalent to 10,000mg/l of available chlorine. A 10:1 dilution of the sodium hypochlorite in use may be convenient.

Using disposable latex gloves, the blood should be covered with paper towels, gently flooded with the disinfectant and left for at least two minutes before it is cleared away.

On the poolside, the affected area can then be washed with pool water (and the washings disposed of, not in the pool). Elsewhere, the disinfected area should be washed with water and detergent and, if possible, left to dry.

The bagged paper towels and gloves are classed as offensive/hygiene waste and in only small quantities can be disposed of with the general waste.

Vomit

It is not unusual for swimmers to vomit slightly. It often results from swallowing too much water, or over-exertion, and so is very unlikely to present a threat through infection.

But if the contents of the stomach are vomited into a pool, the bather may be suffering from a gastrointestinal infection. And if that is cryptosporidiosis, infective, chlorine- resistant cryptosporidium oocysts will be present. This is a rather theoretical, unevaluated risk, and there is some disagreement about how it should be dealt with.

PWTAG recommends that vomit in the pool should be treated as if it were blood (same for vomit on the poolside). See above for details.

Meanwhile, pool operators need to decide what their response will be and have written procedures in place. If they follow PWTAG guidelines, vomiting would result in temporarily clearing the pool of people, scooping up vomit where possible and allowing the pollution to disperse and any infective particles to be neutralised by the residual disinfectant.

Operators need to confirm that disinfectant residuals and pH values are within the recommended ranges; bathing can then resume.

Knowledge Test (check answers with tutor)

The typical starting point for determining occupancy ratio (or, instantaneous bather load) is how many metres squared of water per pool user?

What are the three categories of pollution that can affect pools?

What area of the body does legionella infect?

How often should non-domestic pools be getting the pool water tested at a UKAS-accredited laboratory for microbiological contamination?

The pollution on bather bodies is what makes up most of the pollution in a pool

- ○ False
- ○ True

What are the minimum and maximum water temperatures that can support legionella bacteria multiplication?

Min = ☐ degrees Celcius

Max = ☐ degrees Celcius

Which of the following germs are resistant to chlorine?

- E Coli
- Legionella
- Cryptosporidia

Small amounts of blood, eg.: from a nose bleed, will be quickly dispersed and any germs present killed by the disinfectant in the water

- False
- True

Which type of pool would be expected to have a higher level of ***relative pollution***?

- A diving pool
- An Olympic pool
- A commercial spa pool

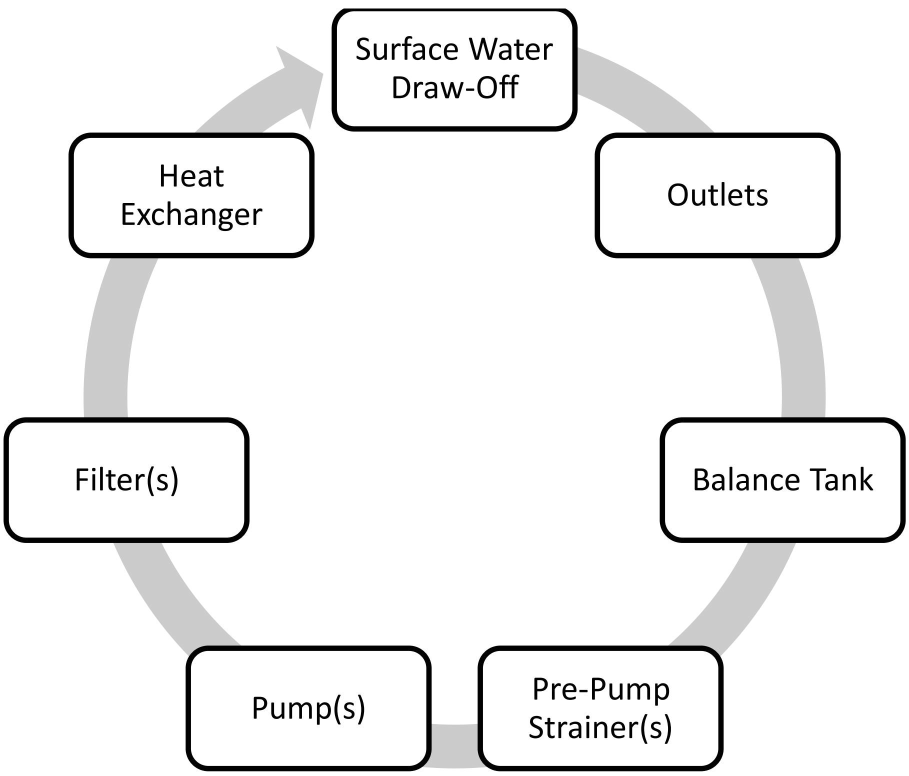
03. Swimming Pool Design and Operation

On completion of this lesson, you'll know about the main components of a typical pool plant system and how they work. You'll understand the sequence these components occur in a system and be able to conduct a survey of a pool plant system. You'll also understand some of the issues that can affect the wider swimming pool building and how to deal with them.

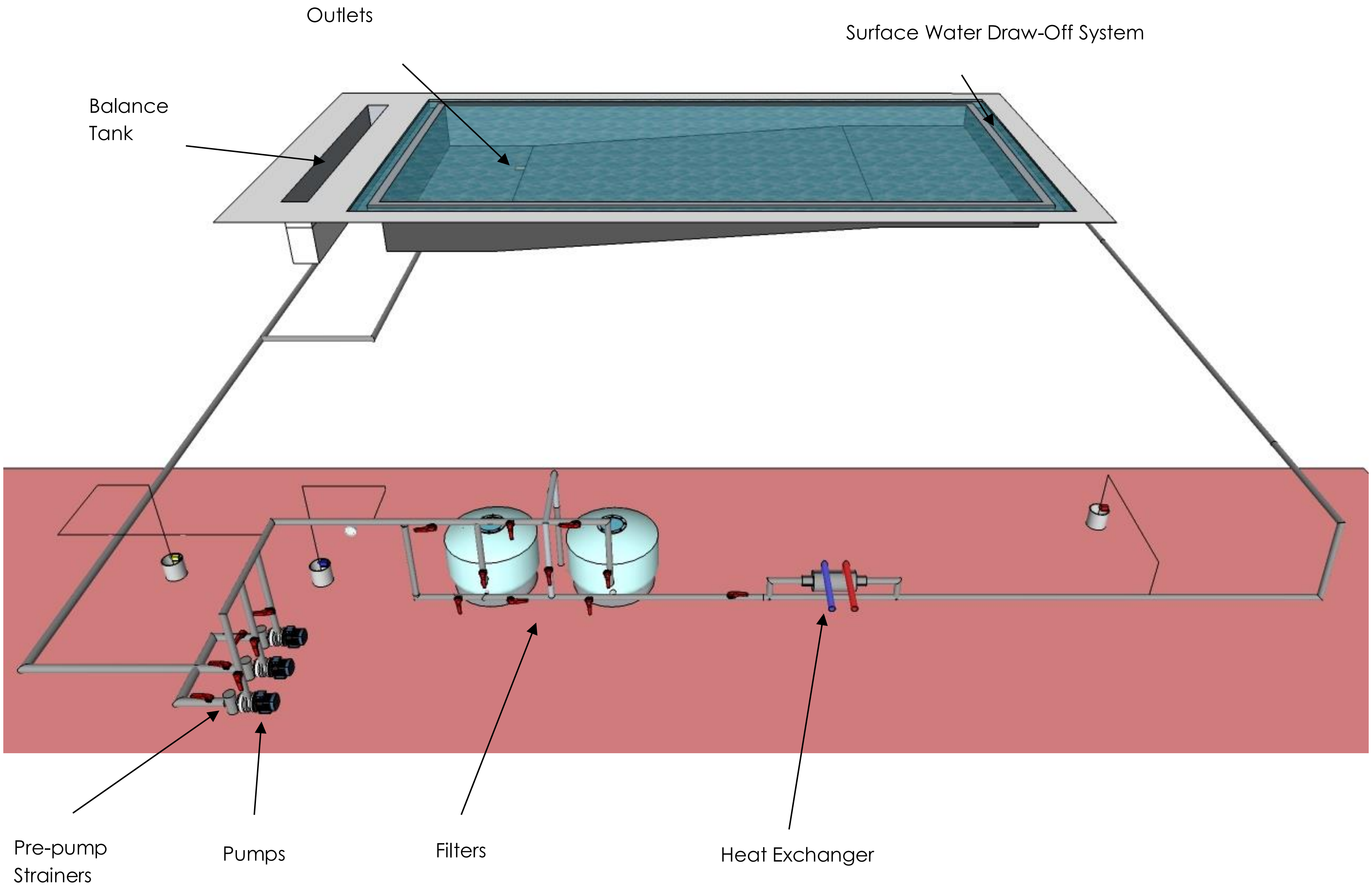
Basic Overview

For the purposes of this course, we are going to consider the circulation system as everything the pool water flows through as it makes it journey from the pool to the plant room, and back to the pool again. Substances that are injected into the pool water as it travels through the circulation system (such as disinfects and other chemicals) will not be included in this discussion of the circulation system but will be covered in detail elsewhere in the manual.

The circulation system comprises the following components:



These components are indicated on the following picture and a brief description of each component is given afterwards.


Outlets
Surface Water Draw-Off System
Balance Tank
Pre-pump Strainers
Pumps
Filters
Heat Exchanger

Surface Water Draw-Off System

Most of the pollution in a swimming pool will sit in the top 150mm of pool depth. Therefore, there needs to be an effective system for removing as much of this pollution as possible. There are three different types of surface water removal system:

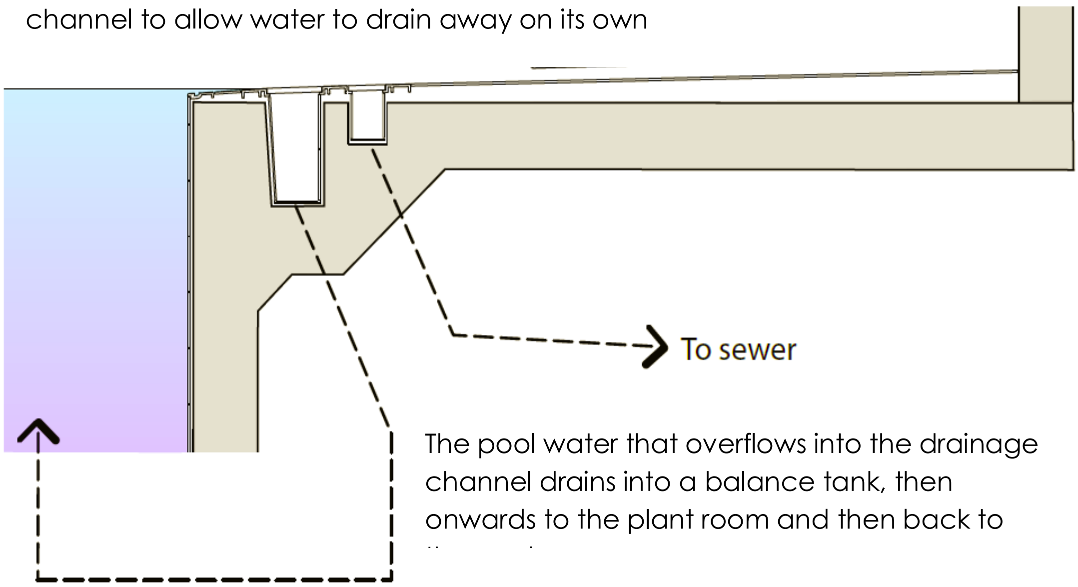
- Deck-level
- Skimmer
- Scum trough

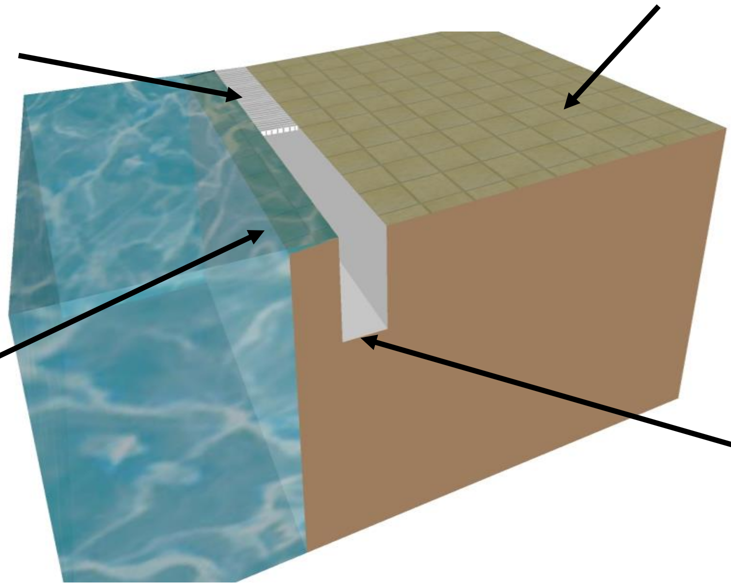
Most of the pollution in a swimming pool will sit in the top 150mm of pool depth

Which system is installed on a pool is largely down to when the pool was built. Deck-level systems are the newest type, scum trough systems are the oldest. Each system has varying degrees of effectiveness at removing surface water pollution. How much pollution is removed is dependent on how much water exits the pool at the surface. With the scum trough and skimmer systems, 20% of the water leaving the pool to be circulated around the system is leaving at the surface, with the other 80% leaving at the floor outlet grills, which are usually located at the bottom of the deep end in a typical swimming pool. With the deck-level system, the situation is vice-versa, with 80% of the water leaving at the surface, with 20% leaving at the floor outlet grills. This makes the deck-level system the best of the three at removing surface water pollution.

Deck-Level System

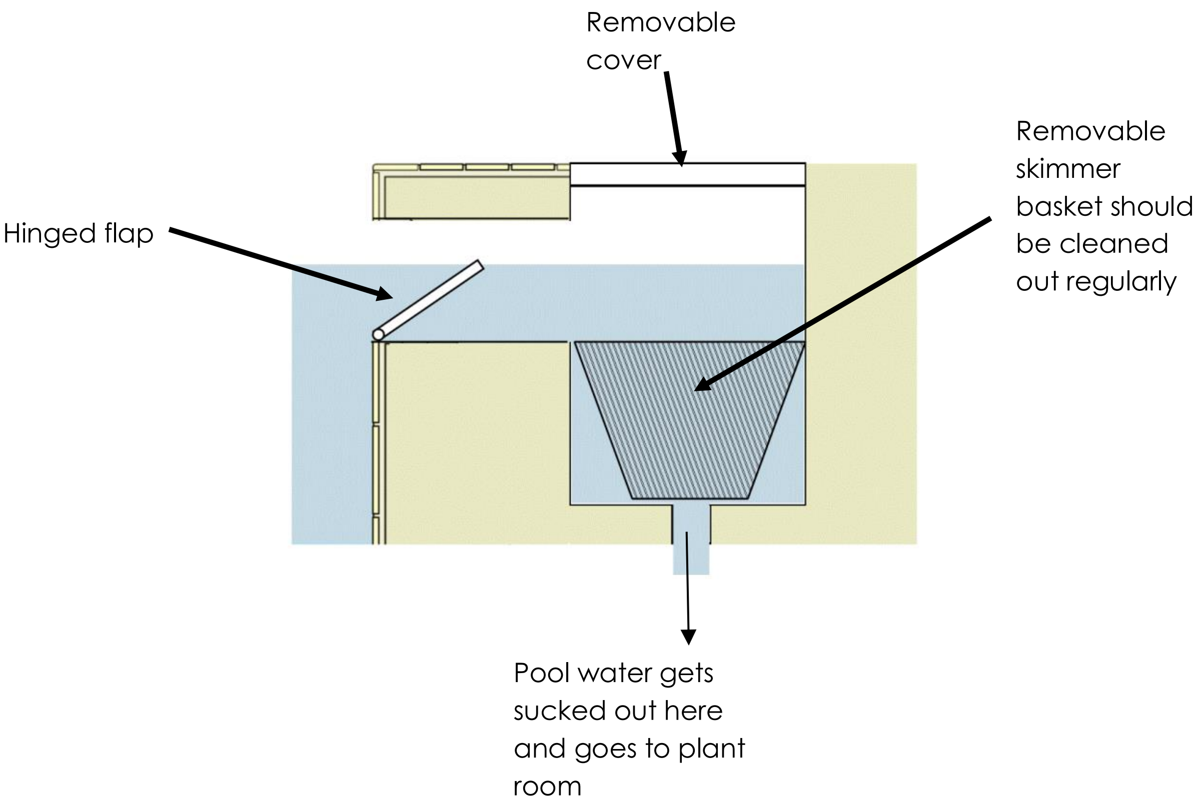
The surface of the pool water is level with the deck of the pool, with water constantly overflowing into a transfer channel which goes around the perimeter of the pool. This is a very effective system for removing pollution on the surface of the water. With this system, 80% of the pool water leaving the pool is leaving via the surface and 20% is leaving via the outlet sumps.


The pool deck is laid to falls, which means that the floor slopes downwards slightly towards the drainage channel to allow water to drain away on its own
To sewer
The pool water that overflows into the drainage channel drains into a balance tank, then onwards to the plant room and then back to


Pool Deck (surround)
Channel Cover
Pool water overflows here into the drainage channel
Water collects in drainage channel and flows into balance tank via gravity

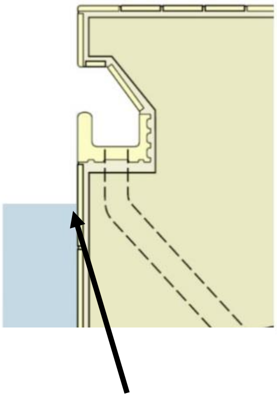
Skimmer Basket System

This system involves several skimmer baskets built in to the pool deck. Water enters the baskets through rectangular opening in the pool wall. The baskets trap the larger particles of surface pollution and have to be removed for cleaning on a regular basis.

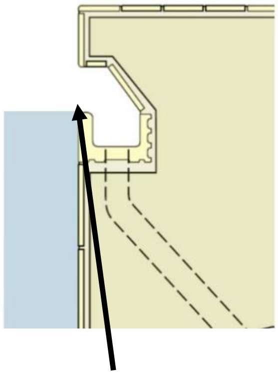


Scum Trough System

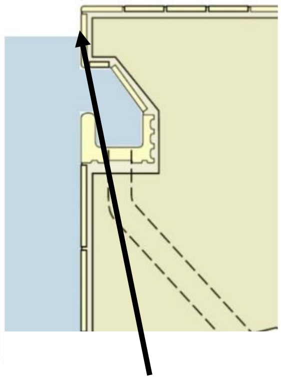
With this system, the pool water overflows into a trough that is built in to the pool wall. Providing that the pool water level is at just the right place, the water will overflow as intended, thus removing the surface water pollution. If however, the pool water level is too high, or too low, the water will not overflow and instead will lap against the sides of the pool, forming a scum line over time. As well as looking very unsightly, this scum line will harbour bacteria as a biofilm will gradually start to build up. This biofilm will serve to protect any bacteria against the disinfectant in the pool water and also be a source of nutrition.



Water level too low. Scum line will be formed here and there is also a risk of air, being drawn into the circulation system.



Water level is correct. Water will overflow into the drainage channel, taking



Water level is too high. Scum line will be formed here. Water will also lap over the

Quickly Remove Excess Physical Pollution on Pool Surface

Excess physical pollution floating on the surface of the swimming pool can sometimes cause a problem for pool plant operators. The heavier physical pollution sinks to the bottom, but the lighter stuff remains floating around on the surface and looks extremely off-putting to pool users. This type pollution usually consists of things like; bits of float, plasters, hair etc. There will also be chemical pollution sitting on or around the surface of the pool, consisting of such elements as biofilm, grease, sweat, mucus etc.

Modern pools are usually deck-level, meaning that the surface of the swimming pool is level with the deck of the pool surround. This system is very good at removing much of this pollution that resides on the surface, and within the top 150mm. because as the water laps over the edge of the pool, the pollution enters the drainage channel that goes around the perimeter of the pool.

In older pools, the deck-level system is not so common and instead, there may be a skimmer system or a scum trough channel. The skimmer system is not very good at removing pollution from the surface as the skimmers do not go around the entire perimeter of the pool like a deck-level drainage channel does, so not nearly enough surface water goes through the skimmer for this to be an effective system. The scum trough channel system isn't any better because if the pool level is too high or too low, the swimming pool water will not flow over the channel in the correct way and you'll end up with what is known as a 'scum-line', which needs to be regularly scrubbed off manually.

If you've got either of the older systems (scum trough or skimmer), chances are that at some point you've experienced going on to poolside and seeing excess debris floating around on the surface with a public swim session about to commence in a few minutes. There is a quick and easy technique that you could use to quickly and easily bring the swimming pool back to a reasonable standard of appearance in order bring the appearance of the swimming pool back to an acceptable standard. You'll need two people, a rope that is as long as the width of the pool and a few towels.

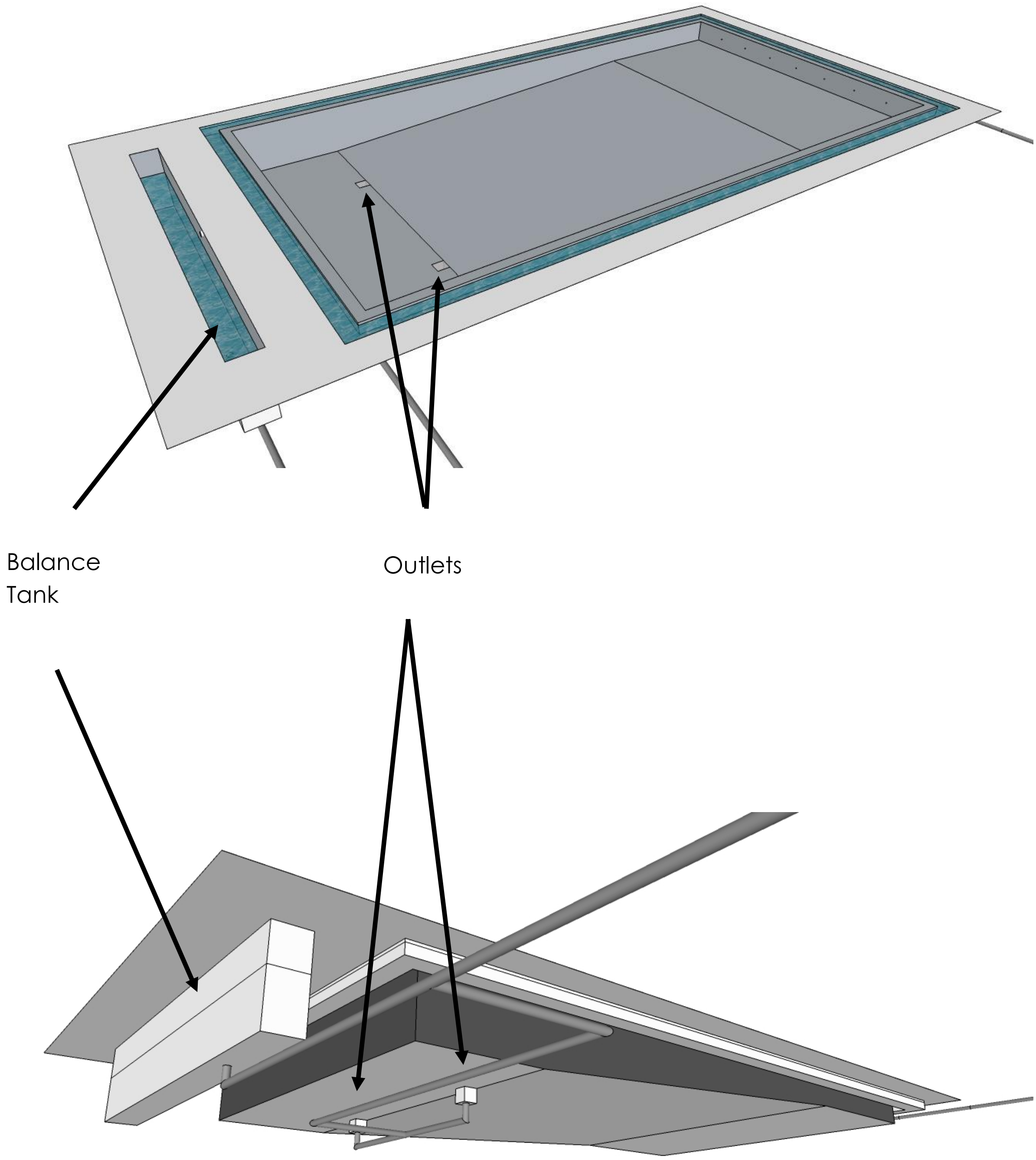
- Drape the towels over the length of the rope while it's lying on the poolside.
- Get one person on each side of the pool and slowly drag the rope down the length of the pool, from shallow to deep.
- What you should see is the towels acting as a filter/barrier. It will catch some of the smaller particles in the material of the towels, while at the same time push some of the larger particles towards the deep end outlets. You will probably also need to get the nets out and spend a few minutes going over the pool surface and collecting any debris that remains.
- After you've completed this process, which should only take a matter of minutes, you should see that the appearance of the swimming pool has been greatly improved.

It should be stressed that this technique is a 'quick fix' only in order to get you out of trouble when you're under pressure. If any of the pool water test results are outside the correct parameters, then the appropriate action should be taken. But if all test results are satisfactory, then this method should come in handy. If you're experiencing this problem regularly, it is an indication that there is an underlying problem somewhere. The pool plant operator should ask the following questions:

- Are swimmers taking pre-swim showers?
- Is the bathing load too high?
- Is the correct circulation rate being achieved?
- Is there enough fresh water going in (30 litres, per bather, per day)?
- Are backwashes being carried out frequently enough?
- Are the skimmer baskets being cleaned out frequently enough?
- Are you using a coagulant, and are you dosing it correctly?
- Is the skimmer valve closed, or being throttled back for any reason?

Outlets

As well as leaving the pool via the surface water draw off system, water is also leaving via the outlets (drains). In a traditional swimming pool, these outlets are usually located on the floor of the deep end and are covered with a square grill. The following pictures show the outlets from above and below the pool tank.



Balance Tank and Pool Outlets (drains)

The outlets of a swimming/spa pool can be extremely hazardous. The hazards are groups under the headings of entrapment hazards and entanglement hazards.

Entrapment Hazards

The outlets of a swimming/spa pool are connected to a powerful circulation pumping system. If the outlets are blocked, whatever is causing the blockage will be exposed to the suction force of the circulation pumping system. The circulation pumps will be sucking on whatever is causing the blockage, causing a vacuum. At this point, it will be very difficult to remove the blockage without turning off the circulation pump(s). If the blockage is a person, then tragic consequences can occur, including drowning, disembowelment and transanal evisceration, which is where internal organs are forcefully drawn out through the anus.

There are various ways that suction entrapment can be avoided:

- Emergency cut-off devices that automatically turn off the suction pumps when an increase in suction force is detected
- Multiple outlets being fitted so that even if one of the outlets gets covered, the remaining outlets take the increased water flow and prevent a vacuum being created at the blocked outlet. The distance between outlets should be a minimum of 2m.
- Outlets being designed so that it is impossible to cover them and form a seal. This can be achieved via having the grill surface area of sufficient size (the outlet should have a surface area greater than $1m^2$).
- It can also be achieved by the use of outlets that are designed to prevent a seal being formed around them when they are covered. These are called anti-vortex drain covers. Some examples below.
- Installing a break tank between the pool tank and the circulation system. The break tank is gravity fed, so there is no risk of being exposed to the suction of the circulation pump(s).
- Ensuring that the water velocity through each outlet is 0.5m/s or less.
- All outlets should be fitted to a sump where the outlet pipe is located a distance 1.5 x the pipe diameter from the grid.
- To prevent finger and toe entrapment the gap in the grille covering the outlet shall be a maximum of 8mm.
- Ensuring that all outlet fittings and fixtures comply with BS EN 13451–1 and 3.

There are also fittings that can be placed over a drain cover that is not an anti-vortex type that will go some way to gaining a similar effect.

Drain covers must be maintained. The picture here is an example of a drain cover that has been allowed to fall into a state of disrepair, with obvious hazards. In order to prevent children getting fingers/toes trapped in the grill, the apertures should be no wider than 8mm.

Once the above design-based precautions have been considered, other precautions can be implemented such as providing training for all relevant staff regarding the dangers of suction entrapment

Entanglement Hazards

Entanglement hazards are slightly different to entrapment hazards. They involve hair being drawn into the outlet and then entwining on the other side of the outlet due to the circular motion of the water is it goes through the outlet. It may be impossible to free the hair from the outlet, even if the circulation pumps are turned off. People using spa pools are at an increased risk of suction entanglement due to the fact that they will be in close proximity to an outlet no matter where they are situated within the spa pool. For this reason, people using spa pools should be advised to tie long hair back and refrain from submerging their head under the water. Staff responsible for supervising the spa pool should be trained sufficiently so that they are aware of the hazards associated with outlets.

Balance Tank

Balance tanks are designed to ensure that the water in the pool remains at the correct level. In pools with a deck-level surface water drainage system, a balance tank is essential. This is because in a deck-level pool, the pool water is constantly overflowing at the surface into the drainage channel. If, for example, 50 people got into an empty deck level pool at the same time, an equivalent volume of water would overflow into the drainage channels. If those 50 people then all got out straight away, the pool water level would drop significantly and water would no longer be overflowing into the drainage channels, thus disabling the functionality of the surface water draw-off system, which is to remove the pollution at the pool water surface. Pools with scum trough and skimmer surface drainage systems don't always have a balance tank, but those that do will enjoy much better water quality.

Balance tanks also enable the backwashing (discussed later) of the filters to take place without it having an effect on the pool water levels as the water in the balance is used to carry out the backwash, rather than the water in the pool. Balance tanks operate in a broadly similar way to a toilet cistern. When a toilet is flushed, the cistern (balance tank) empties and then get re-filled with fresh water until it reaches the ball-cock valve at the top of the cistern that automatically shut off the fresh water supply valve.

Swimming pool balance tanks need to be emptied and cleaned on an annual basis, with spa pool balance tanks requiring cleaning on a weekly basis. Swimming pool balance tanks should be regarded as confined spaces and therefore, a 'permit to work' system should be used to ensure that the job is undertaken safely.

Pre-Pump Strainer(s)

After the balance tank (if there is one) the pool water is pulled under suction into the plant room. In here it must go through a series of various components that will always occur in the same order:

1) Pre-pump strainers(s)

2) Pump(s)

3) Filter(s)

4) Heat exchanger

The pre-pump strainer is designed to trap the larger items of physical pollution before they can get into the pump itself, where it would cause damage. The strainer basket sits inside a vessel and can be removed for cleaning. They will need to be cleaned out regularly in order to prevent them becoming completely blocked with debris. Here is an example of a pre-pump strainer that has been allowed to accumulate too much debris. The pre-pump strainer is a separate component to the pump on large systems, but on smaller systems it is usually an integral component of the pump.

Both types (separate and integrated) have lids which can be removed in order to take the strainer basket out for cleaning. The integrated type usually can a lid that is see-though and can be turned anti-clockwise on a thread. The strainer vessels that are separate to the pump usually have more robust lids that bolted down onto the strainer vessel. Care must be taken when replacing the lids after having had the strainer vessel open as it can often be the case that the rubber O-ring that forms an airtight seal between the lid and the strainer vessel can be misaligned when replacing the lids and therefore wont form a good, airtight seal and will start to suck air into the circulation system when the circulation pumps are turned on.

Instead of attempting to clean the strainer baskets when they are wet, have enough of them in the plant room so that you can rotate them. When it’s time to clean the strainer baskets, take out the dirty one and replace it with the clean one that you have already cleaned. Then leave the dirty strainer basket in a safe place to dry out and then remove the debris and repeat the process the next time.

Circulation Pumps

The circulation pumps are the ‘heart’ of the circulation system. They are designed to continuously pumps water around the system at a pre-determined rate called the flow rate. In larger installations there are usually several pumps working at the same time, with additional pump(s) on standby. In smaller installations, there may only be one single pump.

They work by having an impeller (which is similar to a propeller), which is housed within the pump casing and is connected to an electric motor, which rotates it at high speed. This causes water to be sucked into the pump on the suction side and forced out of the pump on the delivery side.

Filters

Filtration is an essential part of swimming pool water treatment and its importance has been emphasised in recent years due to several outbreaks of cryptosporidiosis, because this organism is not killed by the disinfectant in the pool water and therefore must be removed by filtration in order to prevent bathers becoming infected by it.

Filtration is a fairly simple process; water leaves the pool via the deep end outlets and the surface water draw-off system (deck-level, skimmer baskets, overflow channels etc.). It is piped to the plant room and gets directed into the top of the filter (or several filters in large pools), passes through the filter media (usually sand) where all the contaminants and pollution are trapped and the pool water comes out of the bottom and continues through the remaining components of the pool plant system.

There are 3 main processes happening during filtration:

- Straining
- Sedimentation
- Adsorption

Straining - Involves dirty water passing through the filter media and particles of pollution becoming trapped in the small gaps (pores) between the grains of sand because they are too large to pass through.

Sedimentation - This is where fine particulate matter settles on the upward-facing surfaces of the sand grains. The process of sedimentation can remove finer particles of pollution than straining. As the amount of sediment increases, the amount of space in between sand grains (pores) decreases. This will cause the velocity of water through the filter to increase. Further sedimentation can then no longer occur and, due to the higher velocity, some sediment could get pushed further down into the filter bed.

Adsorption - This is where particles of pollution adhere to the sand grains. It is not to be confused with absorption. With adsorption, very small particles of pollution adhere to the surface of the sand grains. This process is promoted by electrostatic charges within the particles (similar to a balloon 'sticking' to a wall). Once particles begin to adhere to the sand grains, a sticky coating builds up, which promotes further adherence of particles onto the filter media.

Heat Exchanger

The heat exchanger is usually the final component that the pool water is circulated through before it is returned to the swimming pool. There are two types of heat exchanger used in pool plant. They are the coil heat exchanger and the plate heat exchanger. The plate heat exchanger is the newer type and is more efficient at heat exchange than the older coil heat exchanger, although the principles on which they work are very similar.

Water is heated by the boiler and circulated through copper pipes around the building. This is called the domestic hot water (DHW) and supplies hot water to the hot water taps and showers etc. It also gets piped to the heat exchanger where it either flows through a coiled pipe (usually made of copper) or in between plates (usually made of stainless steel), depending on what type of heat exchanger is installed. Swimming pool water also gets directed to the heat exchanger and flows through the chamber containing the coil (if a coil heat exchanger is installed, or in between the hot plates (if a plate heat exchanger is installed).

The pool water never actually mixes with the domestic water, but picks up the heat it requires from the coil or the plates before being circulated back to the pool. The temperature is controlled via a motorised valve fitted to the domestic how water flow pipe, which is connected to a thermostat and automatically opens and closed the motorised valve depending on whether more or less heat is required.

The temperature that needs to be achieved in the pool will depend upon the type of pool and the type of clientele. Most average users of public swimming pools seem to favour higher temperatures. The recommended temperatures for a range of pools are given below.

Recommended Pool Temperatures

Competitive swimming, training etc.	28°C
Recreational swimming	29°C
Leisure pools	30°C
Children's swimming lessons	31°C
Babies and disabled swimmers	32°C
Hydrotherapy pools	35°C
Spa pools	40°C

Valves

The method of regulating the flow and direction of water through the system is via the use of valves. The main type of valve used, especially on larger installations is a butterfly valve, which consists of a disc that is either open, partially closed, or fully closed. They should be inspected and maintained on a regular basis and should not be operated while the circulation is on, unless they were designed to be. Normal practice is to turn the circulation off before opening or closing valves in order to prevent possible shock pressure.

Butterfly Valves

Butterfly Valve – one of the most common on swimming pool systems. Turning the handle rotates a disc within the pipework, thus opening or closing the valve.

Multi-port valves

Smaller swimming pool filter are often fitted with a multi-port valve. As the name suggests, this type of valve has multiple ports which allows one valve to do all the several functions of normal filtration, backwash and rinse etc. There is a single valve handle-lever on top of the unit which is pressed down and rotated according to what function is required at the time. This action closes off certain chambers within the valve casing, whilst simultaneously closing off others in order to redirect the path of the circulation flow.

Swimming Pool Design Considerations

Pool tank

Emptying and Refilling

The first thing to consider before going ahead with this task is whether it is really necessary to empty the pool at all. Many repairs to the pool lining and/or tiles etc. can be carried out by trained divers, without the need to empty the swimming pool at all. A lot of structural damage can be done to the construction if this task is not carried out correctly.

However, there are occasions where the pool water will need to be emptied. An example would be if any broken glass somehow found its way into the pool water. Because glass is completely invisible when submerged in water, the entire pool contents would need to be emptied and a thorough clean-up operation carried out to ensure that all traces of glass have been removed.

If you have assessed the requirement to empty and have decided to go ahead, here's what you should do:

1. Carry out a suitable and sufficient risk assessment for this job before going ahead with anything. This risk assessment will need to be carried out by a person who is competent and understands all of the hazards and risks involved.
2. Contact the local water supplier and the Environment Agency and inform them of what you intend to do. You may need their explicit permission before going ahead. Also, they will require you to remove all of the chlorine from the water prior to discharging and may also require you to discharge the water at a slower rate than you were originally intending.
3. Before releasing any water, turn off the air and water heating system and let the temperature come down to as close to the ambient temperature as possible.
4. Neutralise all of the chlorine in the water using sodium thiosulphate. Every 1 gram of free chlorine will need 5 grams of sodium thiosulphate to neutralise it. For example, if your pool volume is 450 cubic metres and your free chlorine reading is 2.0 mg/l, then there is 900 grams of free chlorine. Times this by 5 (4500g) and you have the amount of sodium thiosulphate you will need to add.
5. Start discharging the water. This needs to be done slowly, at a rate of no more than 750mm per 24 hour period. So for a pool that's 2 metres deep, it's going to take the best part of 3 days to empty it.
6. Before refilling, try to get the pool tiles to as close as possible to the incoming water temperature. This will obviously be more difficult to achieve in the winter months, so have a think about when would be the best time to schedule this work. Heat the water slowly at a rate of no more than 0.25 degrees Celsius per hour. So if the water is, say, 5 degrees Celsius, you may be looking at a four-day period in order to get it up to bathing temperature.

If a pool is emptied, then the bottom and sides should be scrubbed thoroughly with 10 mg/l chlorinated water before refilling. It should be flushed thoroughly to drain before refilling. Check the integrity of the structure while the pool is empty.

Pool tank profile

It is recommended that all pool profiles are based on a number of important safety principles:

- abrupt changes in depth should be avoided in water less than 1.5 m in depth;
- steep gradients should be avoided - a maximum gradient of 1 in 15 is recommended for water depths up to 1.5 m;
- changes in depth should be clearly identified by the use of colour-contrasted materials or patterned finishes so as to indicate to bathers when they are proceeding to water of a different depth. Where colour is used, this should not reduce the visibility of a body lying on the pool bottom;
- a minimum water depth of 1 m is recommended for larger pools used for training and/or competition. For small community pools without a separate learner pool, a depth of 900 mm is recommended because this is more appropriate to young children and for teaching purposes.

The introduction of a movable floor(s)/bulkhead(s) will affect the pool tank profile and will create a wider range of different profiles. Care should be taken to ensure no additional hazards are created. The overall profile should still meet the above principles and where this is impractical, or cannot be achieved, options for controlling any potential hazards need to be considered.

Pool tank edge

The pool tank edge should be colour-contrasted with the pool water so as to render it clearly visible to bathers in the water and on the pool surround. This is particularly important for deck-level pools where the pool edge may be partially submerged.

Fixed raised pool ends are recommended for main pools with deck-level edge channels, where a pool is used predominantly for training and/or racing. The raised ends help the swimmer to easily identify the end walls of the tank.

In a leisure pool where the pool tank bottom slopes gently from a beach area to deeper water, there is no need to highlight the water's edge providing there are no 'upstands' or steps between the pool and its surrounds.

Pool tank detailing

It is recommended that the detailed design of the pool tank should ensure that:

- The pool tank should have no sharp edges or projections that could cause injury to bathers, especially below the water level. Careful consideration will need to be given to the design of recesses, ledges, or rails so as to ensure that they are not a hazard;
- Wave machine openings, sumps, or inlets and outlets of the pool water circulation system should have suitable protective covers or grilles. They should be designed to prevent limbs and fingers getting trapped. Undue suction should not be created, which could result in a body being held against a grille, and there should be no exposed sharp edges. This is particularly important in areas of moving water;
- There should be at least two outlets per suction line at a sufficient distance apart to prevent a body being drawn or trapped by two suction line outlets. The amount of suction produced at any single outlet position should not be sufficient to result in a body being drawn towards it and held in position or entangle hair;
- where handrails are provided, they should be recessed into the pool tank in such a way that it is not possible for limbs to become trapped between the grab-rail and the rear wall of the recess or the tank wall;
- If a resting ledge is to be provided this should be recessed into the pool wall. If, for some reason, this is not possible, the ledge should be colour-contrasted and warning signs displayed to alert bathers, who are entering the water, to its presence.
- If tiles are used for the pool tank lining, epoxy grouts should be used as these are resistant to grout attack.

Pool tank bottom

A slip-resistant and non-abrasive finish should be provided in the following areas:

- on the end walls of the pool as a turning pad to aid tumble turns or for swimmers starting backstroke events;
- in leisure pools on the beach area and other shallow water areas where bathers may become unbalanced when a wave machine or other feature is operating.

If racing lines are not to be included then a line running along the centre of the pool will assist bathers to determine sudden changes in water depth. The ability to see the bottom of the pool clearly is essential to effective lifeguarding.

Pool floor patterns which would make it more difficult to recognise a body at the bottom of the pool should not be used.

The pool bottom should be kept clear of contamination, algae, and general debris by daily sweeping, suction cleaning or other means. This is especially important with deck-level pools because up to 80% of the water flow can be leaving via the surface, meaning that there will not be much water flow at the bottom of the pool to help keep it clean and free of algae and other staining.

Access to the pool tank

Access to a pool tank may be provided by built-in steps or ladders according to the type of pool. These should provide easy and safe entry to, and exit from, the water. Fewer entry points may be needed where the pool edge is of deck-level type since many bathers find it easier to enter and leave this type of pool directly from the poolside.

Entry steps and ladders should not interfere with the use of the pool for competition or training and should be recessed so as not to disrupt or endanger swimmers. The most appropriate arrangements for access are suggested as follows:

- for main pools, by means of a recessed ladder at each end of the pool tank in each side wall, approximately 1 m from the pool tank end wall. Additional steps at the mid-point of the tank could also be considered;
- for learner pools, by means of steps running along part of the pool. In irregular-shaped pools these can be designed to follow the shape of the tank. Intermediate handrails should be provided;
- for leisure pools with high freeboards, recessed steps allowing entry and exit from all water areas should normally be located not more than 15 m apart;
- for splashdown pools, the exit steps should be at the opposite end to the slide exit point.

Movable floors and bulkheads

Movable floors are being used more extensively to change the water depth over part or all of the pool tank area in order to achieve greater programming flexibility. They allow more activities to be accommodated within a single pool area or improve activities that may be compromised by a fixed depth of water. There is evidence of greater through-put and reduced net operating cost where they are used, particularly for 50 m pools.

The use of this technique to create a ‘dry’ activities space is usually limited by the wet humid conditions within the pool hall. However, learner pool floors which can be raised to the level of the pool deck surround, are sometimes used as a holding area for competitors when an event is taking place in the main pool.

Movable floors can be adjusted from a depth of a few centimetres for carer and baby classes to a safe depth of 5 m for a person diving from a 10 m diving board.

Where a movable floor is provided as part of a learner pool, automatically folding steps can be integrated with the movable floor to allow mother and child, or those with ambulant disabilities, to access the pool with greater ease, regardless of its set depth.

The turnover period of pools with moveable floors should be appropriate to the pool at its shallowest point (ie potentially biggest bathing load).

There are two types of bulkheads: those which traverse laterally (and when not in use, are stationed at one end of the pool); and those which move vertically (and when in their lowered position, are housed in a recess in the pool floor).

Bulkheads can be used to:

- Divide the water area so it can be used for different activities simultaneously. This is often desirable for safety reasons
- Reduce the length of an existing pool to 25 m, the length recognised by the ASA for training and competition
- Provide measurable distances where accuracy is important
- Provide a safety barrier to the edge of a movable floor.

If possible, moveable floors and bulkheads should be brought to the surface and tilted so that both surfaces (including the underside) can be cleaned. This may be required every 6 months.

If moveable floors do not tilt for cleaning, they should have access hatches or manholes to allow access. Cleaning then requires specialist divers who should work to the Diving at Work Regulations 1997.

Inlets and Outlets

Inlets and outlets, grilles and covers should be designed in accordance with BS EN 13451-3. They should be inspected visually every day and once a month subject to closer examination for obstruction, impact damage and vandalism and to make sure that they are correctly in place. If they are damaged or missing, swimming should be suspended immediately.

Inlets: in water less than 800mm in depth and in sensitive areas (steps, teaching points, beside base inlets, etc.) the velocity of the water entering the pool should not exceed 0.5m/s. In other areas, the velocity of the water entering the pool should not exceed 2.0m/s.

Outlets can cause entrapment and therefore have the capacity for serious harm. PWTAG guidance is that all pools should be tested to show that outlets comply with BS EN 13451-3. New completed pools should have this certification when built. Where this is not the case, pool outlets should be tested by a competent authority to show that they comply.

Outlets should also be tested for hair entanglement.

Pool outlets should be designed and installed so as to reduce the potential for entrapment of the user. As a general requirement, water speed through the outlet grilles should be ≤0.5m/s.

Grilles in outlets and inlets should comply with the requirements of BS EN 13451-1 and have gaps no greater than 8mm to prevent entrapment hazards.

All wall and floor outlets should be fitted with a sump to a design that accords with BS EN 13451-3. Additionally at least one of the following two requirements should be met.

- Multiple suction outlet systems should be designed in such a way that: there are at least two functioning suction outlets per suction line the distance between the nearest points of the perimeters of the devices is ≥2m if any one of the suction outlets becomes blocked, the flow through the remaining suction outlet/s shall accommodate 100% of the flow rate
- it is not possible to isolate one of the outlet sump suction lines by means of a valve

In the case of suction outlet systems on existing pools with only one grille, the grille should be designed in such a way that it cannot be blocked:

- one user cannot cover more than 50% of the opening
- raised grilles can be domed opposite to the flow direction, with prevalent peripheral suction; the height of the dome shall be at least 10% of the main dimension single grilles should have a grille area of ≥1m2.

Balance Tanks

Balance tanks should be inspected at least once a year and cleaned as necessary. Debris should be removed and inner surfaces brushed and flushed down with 10mg/l chlorinated water, which can be returned to the circulation system via the filters.

Balance tanks should be regarded as confined spaces, and therefore the legal duties set out in the Confined Spaces Regulations 1997 may well apply.

Pool Covers

Various types of pool cover are available, including simple hand-operated roller systems, automatically deployed covers, rising floors and decks and air-supported domes. Where pool covers are used as the primary means of preventing bathers' access (e.g. in some open-air pools which cannot be locked up after hours), the covers must be of a type which can be secured continuously around the edges. They must be capable of supporting the weight of any person walking or falling onto them and they should also be resistant to vandalism.

Pool operators will need to ensure that their employees are not at risk from hazardous manual handling when dealing with this type of equipment.

Pool covers should be checked regularly on both sides for algal/mould growth and indicators of microbiological contamination and cleaned as necessary with 10mg/l chlorinated water.

Pool covers for spa pools should comply with British Standard 'BS 6920 Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water' because of the risk of colonisation by legionella bacteria. Swimming pools, whilst not a recognised source of legionella bacteria, should ideally be fitted with pool covers that comply with the same standard.

The bacteria pseudomonas aeruginosa has been identified as a reason for microbiological contamination of swimming pool water due to colonisation of the swimming pool cover.

Circulation in 'wet' areas and around the pool

Abrupt changes in floor level, including steps, should be avoided in 'wet' areas wherever possible, including changing rooms, shower areas, toilets and on the pool surround.

Access to the pool hall from changing rooms or pre-swim shower areas should present the bather with water less than 1.2 m in depth. Other features which affect design, such as the location of access stairs to water slides, should avoid the possibility of bathers queuing near deeper water without a protective barrier. Ramps may be provided to give people with disabilities easier access to the pool. If a ramp is provided in a main pool, it should not protrude into the bathing/swimming area.

Where a freeboard rises substantially above 380 mm, consideration should be given to the need for a protective barrier at the pool edge.

The pool surrounds and other circulation areas should be designed so as to ensure the free flow of bathers and the avoidance of congestion. A minimum surround width of **2 m** is recommended, but it may be possible for a narrower width to be used safely in some circumstances. The required width should be determined by reference to:

- how the pool will be used - for instance, whether it will be used for training or competition;
- where people will circulate, taking into consideration entry/exit from changing areas and the pool tank, queues for water features, fire escapes and any other areas where there is the potential for congestion.

In addition, pool operators need to consider what the maximum number of bathers using the pool surround is likely to be at any one time; this should also take into account use by people in wheelchairs.

Design of steps and ladders

Handrails, steps and ladders providing access to the pool:

- must be of sufficient strength and firmly fixed to the surround and tank walls;

- should be designed to ensure that finger, limb and head traps are not created, either between the treads or the tank walls, or between the grab-rails and the tank walls;
- should be designed with their likely user in mind. Steps providing access to learner pools or shallow water should have a shallow riser (between 150 mm and 160 mm) and be wide enough (**300 mm** minimum) to allow easy use by children or an adult carrying a child. The leading edge of each step should be colour-contrasted for increased visibility from both in and out of the water;
- should have treads which are slip-resistant and have no sharp edges;
- should be designed giving consideration to the ease of access to and exit from the pool by users with restricted mobility or those with disabilities.

Design of ramps

Ramps providing access to the pool:

- should have a gradient that does not exceed 1 in 15;
- should have a clear width of 1 m;
- should have a slip-resistant surface;
- should have handrails on both sides of the ramp;
- should have sufficient space at the bottom and top of the ramp for manoeuvring a wheelchair;
- should not, if provided in a main pool, protrude into the competitive area.

Floors

Cleaning

Pool surrounds should be cleaned at the start of each day by washing and scrubbing with water chlorinated to 10mg/l. Proprietary chemical cleaners formulated for pool use may be necessary for stubborn dirt.

Mechanical scrubber driers on separated extra-low voltage (SELV) pick up the water and solution used in cleaning and then dry the surface. These are ideal but should be emptied and disinfected and dried after each use.

Deposits of dirt etc just above the water line of a freeboard pool can be cleaned off with a chemical-free scouring pad, using sodium bicarbonate or carbonate solution. Operators should wear gloves and goggles.

If a deck-level pool surround falls away (to drain) from the transfer channel, lowering the water level in the pool can keep any cleaning residue out of the pool water.

Some pools have a transfer channel, which is capable of being isolated from the pool water system. So for cleaning purposes the pool water level can be lowered (pool circulation stopped) so that water from the pool no longer flows down the channel. Then the transfer channel is used to take any cleaning residue, and by opening the drain valve and thoroughly flushing, the cleaning residue goes to waste.

Proprietary chemical cleaners, if required, should be formulated for poolside use, and come from reputable suppliers (even though the target is to prevent their getting into the pool water). They may contain surfactants that affect the monitoring of chlorine residual and cause foaming or phosphates which promote algal growth. They may contain oxidising agents that give a false reading on water tests. Other compounds simply contain ammonia (they may smell of it) and could produce unhealthy pool conditions (through high combined chlorine levels).

For all these reasons, proprietary cleaners should be avoided altogether if possible. But in any case, every effort should be made to keep cleaning products out of the pool and any transfer channel. Ideally, there should be some way of draining all poolside washings to waste.

Certainly, care should be taken to avoid outright incompatibility between cleaning and pool chemicals, which could be dangerous. Chlorinated isocyanurates – often called trichlor or dichlor – can react violently with neat hypochlorites (particularly calcium hypochlorite). In general, reactions between acid and alkalis are potentially dangerous.

Chemical cleaners – whether for pool surrounds or the water line – should never be used when there are people in the pool.

Periodic removal of hard water scaling and body grease

It may be necessary for all wet areas, pool surrounds, showers, changing rooms and toilets to tackle a build-up of limescale from the water and/or body grease and oils from bathers. Use sodium bicarbonate or carbonate to remove any organic build-up such as body oils or grease. Use an acid-based cleaner (e.g. weak hydrochloric acid/or citric acid) for removing scale. It is important that no residue from these cleaning programmes returns to the pool water.

Slip resistance

Slip and trip hazards can be reduced by good design. Surface roughness, moisture displacement, the profile and surface pattern of the finish and foot-grip, all affect slip resistance. The slip resistance of any given surface will diminish if the gradient becomes steeper than 1 in 30 or is less than 1 in 60 (because such a shallow gradient is not sufficient to ensure that moisture drains away). Where falls outside the recommended range have to be specified, finishes should have a particularly high slip resistance. Floor finishes with different slip-resistance characteristics should not normally be specified in the same area.

The normal recommended range for the fall in wet areas is between 1 in 35 and 1 in 60. When combined with a slip-resistant finish such as a '25-stud' ceramic tile, this should create a satisfactory surface.

Movement joints

Where movement joints are provided in order to meet the requirements of BS 5385: Part 3 1989 (amended 1992),19 the compound used should be as hard as possible so as to reduce the likelihood that it can be pulled out of the joint.

Drainage gullies and transfer channels

Floor gullies, gutters and valleys should not constitute a tripping hazard, and the drainage outlet should have no sharp edges. They should also be easy to maintain and clean.

Deck-level transfer channels should be cleaned as required, at least once a month. They should be drained and flushed out with 10mg/l chlorinated water which can be returned to the balance tank. Grilles should be scrubbed weekly with 10mg/l chlorinated water.

Walls

Wall finishes to circulation areas should be smooth for a height of **2 m** minimum so as not to present a hazard to bathers moving around. Any projecting piers or columns should be provided with a rounded or bull-nosed edge. Consideration should be given to the safety implications of rocks, planting features and structures provided close to walkways.

Glazing

It is essential that any glazing used in the pool area is of the appropriate specification to ensure that it can withstand body impact (BS 6262: Part 4 2005). If the pool is used, for example for water polo, windows will need protection against ball impact, for instance through the use of impact-resistant toughened glass or polycarbonate sheeting or netting. Consideration will need to be given to ways of reducing the amount of glare caused by the glazing which could affect the view of lifeguards and pool users.

Ceilings

The constructional design of ceilings and the roof deck over 'wet' areas should take into account the need to avoid condensation, which can affect the structural integrity of the roof itself. Detailed guidance on this issue can be found in the Handbook of sports and recreational building design (available from Sport England Publications) and is also available from the Advisory Service of the Building Research Establishment. Suspended ceilings should be avoided wherever possible, but if they are essential they should be designed in such a way that allows routine inspection of the ceiling void, internal roof structure and light fittings.

Public toilets

Ideally, toilet facilities should include male and female accessible toilets for users with disabilities. At least one unisex accessible toilet should also be provided.

For small community pools with a limited social/viewing area, a unisex accessible WC compartment should be provided in addition to any accessible provision within the changing areas. For larger facilities, the provision of accessible toilets should be considered in respect of an overall access strategy.

Changing facilities

Swimming pool changing can be designed with either open-plan single-sex areas or as a 'village changing' unisex area with individual cubicles.

The village changing arrangement is usually preferred for the various modes of use. Village changing can provide:

- Greater flexibility to accommodate varying mixes of male and female users, including family changing and changing for people with disabilities
- Flexibility to allow staff of either sex to supervise, clean and maintain the area 29
- Minimise any perceived sense of insecurity for sensitive users 30 by well-designed changing rooms that offer privacy through adequately-sized, good-quality cubicles.

There is scope for variations in both systems with the addition of group single-sex changing rooms, buffer rooms and additional cubicles. This can give a degree of choice for user groups.

Toilets

Toilets should generally be provided in accordance with BS 6465. They should be sited in a prominent position on the route from the changing area to the pool hall, before any pre-swim shower provision. This can be difficult to achieve with mixed-sex 'village' changing layouts where the circulation routes between rows of changing cubicles may lead directly onto the pool surround. Some repetitive circulation is inevitable as the toilets are normally located to one side of the changing area.

Separate-sex toilets are required and need to be designed to accommodate users with disabilities.

In small pools it is more economical to provide a separate accessible unisex WC compartment. This can be planned with access from the pool surround. The toilet design/layout should ensure:

- The toilet and urinal area is screened for privacy

- There are no hidden areas to hinder staff supervision
- There is sufficient circulation space to enable easy access for wheelchair users
- Regular cleaning with a hose
- Robust water-resistant and vandal proof fittings.

Showers

Shower provision should be in accordance with BS 6465 and based on a 50% male and 50% female use of the pool.

For reasons of swimming water hygiene, pre-swim showers should be positioned to encourage their use prior to pool entry. Therefore, they should be positioned close to the pool surround.

In contrast, post-swim shower cubicles should be positioned as close as possible to the lockers in a mixed-sex village changing area or within individual male and female changing areas so that swimmers can conveniently retrieve their soap and towels.

Where cost is a factor, showers can cater for both pre and post-swim needs in one area. They can be planned close to the pool hall or in a recess off the pool surround to allow indirect staff supervision.

Attention should be given to adequate drainage and slip-resistance of the floors to shower areas, to prevent soap creating a hazard.

Footbaths are not considered an effective method of cleaning feet and are an impediment to disabled people – therefore these should not be used. Foot sprays are an alternative, although well-positioned showers that encourage use prior to swimming are the best option.

The shower design and layout should ensure:

- Adequate warm water consistent with water economy
- Dirty water is prevented from entering the pool or, in a deck level pool, the surround channel
- Showers are planned without stepped thresholds and use appropriate falls and floor drainage channels or gullies to remove water
- A number of fully enclosed showers for post-swim showering
- There are waste receptacles close to the shower area for empty shampoo bottles and sachets
- Drop-down shower seats are provided for users with disabilities.

Baby change facilities

Baby changing facilities should be easily accessible. They should be well ventilated and equipped with an adjustable changing shelf, a large purpose made nappy disposal bin and an adjacent washbasin. Provision can be within the male and female toilets and/or by providing one or more unisex accessible rooms with enough space for a parent, 2 children and a push chair (See BS 6465 and BS 8300). This may be integrated into a unisex accessible changing room with toilet, or by providing a dedicated unisex accessible parent and child toilet.

Stainless Steel

Stainless steel fitting and fixtures should be cleaned whenever it has lost its original appearance. How often this is required will vary, some elements may require daily cleaning, others may require only annual cleaning. Detergent is not normally required (water will suffice, unless there is a build-up of body-fats, grease, dirt, scale etc.

Corrosion of stainless steel can occur if there is not adequate control and management of the air quality in the pool hall, especially with regard to the relative humidity, which has a direct influence on the amount of condensation that may settle on to stainless steel elements of the construction. The condensation in a pool hall will inevitably contain aggressive by-products of the disinfection process and this can lead to stress corrosion cracking. This has led to the collapse of supporting structures of suspended ceilings in some pools.

Knowledge Test (check answers with tutor)

Identify the component in the image below.

Fill in the blanks.

[ ] of stainless steel can occur if there is not adequate control and management of the air quality in the pool hall, especially with regard to the relative humidity, which has a direct influence on the amount of [ ] that may settle on to stainless steel elements of the construction. The condensation in a pool hall will inevitably contain aggressive by-products of the disinfection process and this can lead to stress corrosion cracking. This has led to the collapse of supporting structures of suspended ceilings in some pools.

When emptying a swimming pool, the water must be discharged ***SLOWLY***, at a rate of no more than [ ] mm per 24 hour period.

How often should pool inlets and outlets grilles and covers be visually checked?

- Daily
- Weekly
- Monthly

When heating the water in a freshly filled pool, it should be heated at which of the following rates:

- No more than 5 degrees Celsius per hour
- No more than 0.25 degrees Celsius per hour
- No more than 2.5 degrees Celsius per hour

Reorder the pool water treatment functions into the order they would occur in a typical system.

Heating

Acid dosing

Coagulant dosing

Pumping

Filtration

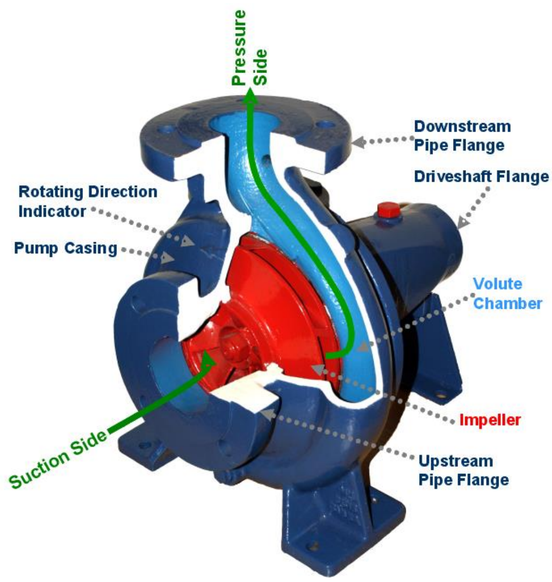
04. Hydraulics and Circulation

On completion of this lesson you'll know how water moves around a system and the hazards that this can present. You'll understand the importance of flow rate and how this relates to turnover.

Circulation

Swimming pool water is circulated around a system so that it can be filtered, heated and chemically treated before being returned to the pool.

Most circulation pumps work via centrifugal action. An outer casing encloses a rotating impeller that draws water in via vacuum suction. On the other side, the water is under pressure and gets forced along the pipework. The pumps must be primed (i.e. flooded with water) at all times for this to happen.



Flow rate

The flow rate is the speed at which water is flowing through the system. Usually expressed as cubic metres per hour and monitored by a component fitted to the system pipework (usually between the pumps and filters) called a ***flow rate meter***.

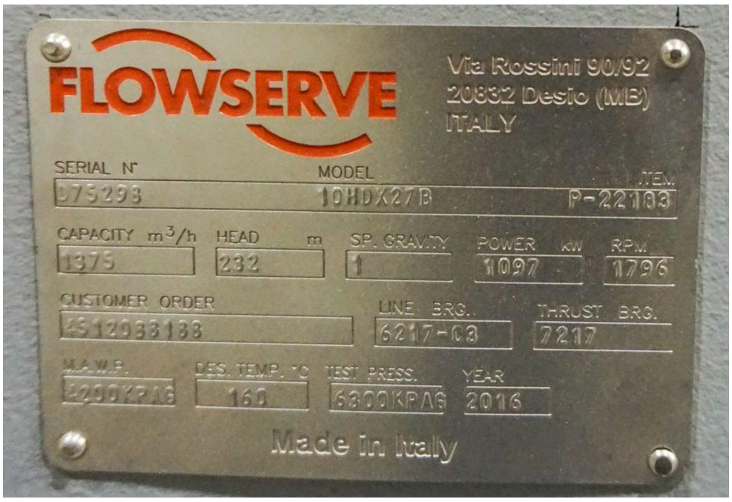
If you cannot locate a flow rate meter on your system, it may be that it wasn't fitted as part of the original installation (unfortunately quite common). You'll need to get one fitted as soon as possible to calculate the turnover time (discussed below).

"It's got the flow rate stamped onto the pump, so we don't need a flow rate meter. Do we?"

Yes!

The flow rate given on the pump is not the same as the flow rate of the system as a whole.

See the image. The pumps data plate gives a flow rate of 1375 cubic metres per hour, but that's the maximum capacity that was tested during production, against no resistance to pumping power.



Turnover time

This is the time it takes to circulate the pool volume around the treatment system. It is calculated by dividing the pool volume by the flow rate.

If the turnover time is too long, pollution levels will start to build up in the pool. If the turnover time is too short, the water will travel too fast through the system. This reduces the effectiveness of filtration (slower filtration is usually better than faster filtration). Recommended turnover times are given below.

Recommended Turnover Times

• Diving Pools	4 - 8 Hours
• Domestic Pools	4 - 8 Hours
• 50m Olympic Pools	3 - 4 Hours
• 25m General Use Pools	2.5 - 3 Hours
• Leisure Pools Over 1.5m Deep	2 - 2.5 Hours
• Leisure Pools 1 - 1.5m Deep	1 - 2 Hours
• Leisure Pools 0.5 - 1m Deep	0.5 - 1.25 Hours
• Leisure Pools Less Than 0.5m Deep	10 - 45 mins
• Hydrotherapy Pools	0.5 - 1.5 Hours
• Teaching Pools	0.5 - 1.5 Hours
• Waterside Splash Pools	0.5 - 1 Hour
• Interactive Water Features	20 mins
• Domestic Spas	15 mins
• Commercial Spas	6 mins
• Leisure Water Bubble Pools	5 - 20 mins

Common Circulation Problems

Loss of prime

This is a situation where the pump and pipework, which under normal conditions is full of water, is empty.

The impeller will be rotating but will not be able to create the vacuum necessary to create the suction required to pull the water through the pipework.

The system can be re-primed but there are serious safety implications (covered in topic: How to safely stop and start circulation).

Air ingress

If air is drawn into the system, it can create problems with visibility in the pool due to the tiny air bubbles that become entrained in the water returning to the pool from the treatment system.

Care must be taken when replacing the lids after having had the strainer vessel open as it can often be the case that the rubber O-ring that forms an airtight seal between the lid and the strainer vessel can be misaligned when replacing the lids and therefore won't form a good, airtight seal and will start to suck air into the circulation system when the circulation pumps are turned on.

Blockages

If problems are encountered with pressure loss, there might be a blockage. One of the most common places where blockages are encountered is in the skimmer baskets, especially with outdoor pools due to leaves etc. There might also be a build up of material in the pre-pump strainer basket if it hasn't been maintained and cleaned out regularly.

Poor Design

Unfortunately, the design and construction of swimming pools and associated treatment systems is not tightly regulated and there are many examples of systems that are poorly designed. Examples of problems include:

- Incorrectly sized pipework
- Incorrect pipework material
- A 'mish-mash' of different pipework materials
- Too many right angled bends
- No valves fitted where there should be valves
- No pressure gauges fitted to filters

- No air bleed system fitted to filters
- No flow rate meter fitted to system

It's not just contractors who are at fault – clients also need to take responsibility for not properly specifying a contract for the work, or selecting a contractor based solely on price, with inadequate consideration given to competence and quality.

How to safely stop and start circulation

It might not seem like a big deal but stopping and starting a commercial swimming pool treatment system is dangerous for those unaware of the hazards! In this topic, we'll go through the issues and discuss a real-life case study where the pool operators gassed several unfortunate swimmers due to procedural errors!

Case Study: David Lloyd Leisure exposes swimming pool users to noxious gas and hospitalises five

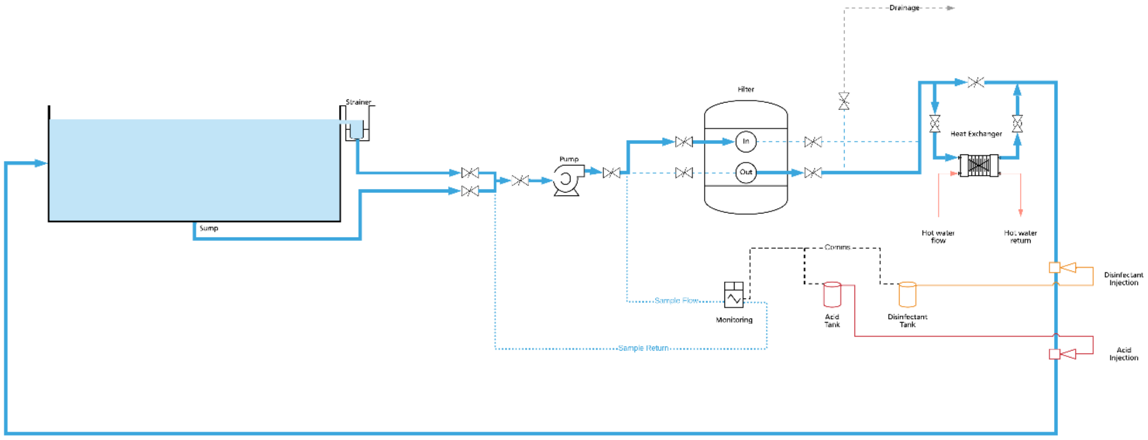
David Lloyd Leisure Limited, the well-known national chain of over 90 health and leisure clubs was prosecuted by Ipswich Borough Council for an offence contrary to section 3(1) of the Health and Safety at Work etc. Act 1974 following a release of noxious gas into the pool hall at its Ipswich branch and was fined £70,000 and ordered to pay £60,000 costs.

Full details here: https://6pumpcourt.co.uk/pascal-bates-prosecutes-david-lloyd-leisure-for-exposing-swimming-pool-users-to-noxious-gas-and-hospitalising-five/

HAZARD WARNING!

There is a risk of the generation and emission of extremely hazardous chemicals when power to the circulation pumps is cut (intentionally or because of power failure). A system should ***NEVER*** be restarted following a failure of the circulation system while there are people in the pool. If there is a concern that there may have been inadvertent mixing of chemicals within the pipework of the circulation system, the fire service should be contacted, and the circulation and chemical dosing systems left stopped.

Look at the diagram and think about what might happen if the circulation pumps are switched off but the chemical dosing continues.



What is the more significant hazard?

1. The chemicals will mix in the pipework between the injection points, creating deadly chlorine gas!
2. The water in the swimming pool will become polluted as there is no filtration or disinfection occurring!

Discuss the issues with your tutor.

"Our chemical dosing shuts off when we turn the circulation pumps off – do we need to worry about this?"	You need to at least check that the chemical dosing system has stopped dosing when the pumps have been turned off – don't assume that the auto-shut-off system will *always* work. They can and do fail.

Outlet Dangers

As well as leaving the pool via the surface water draw-off system, water is also leaving via the sumps (drains). In a traditional swimming pool, these outlets are usually located on the floor of the deep end and are covered with a grill.

HAZARD WARNING!

The outlets of a swimming/spa pool can be ***extremely hazardous!***

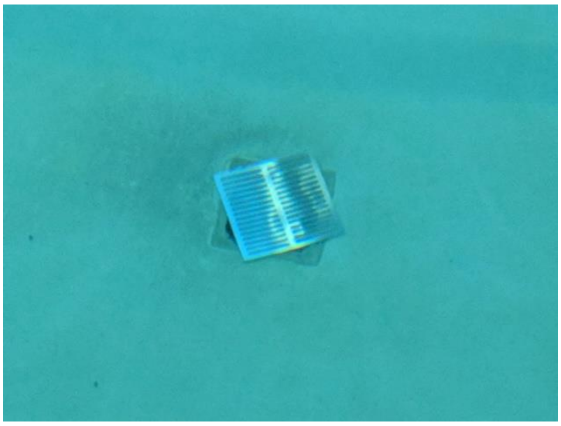
Entrapment hazards

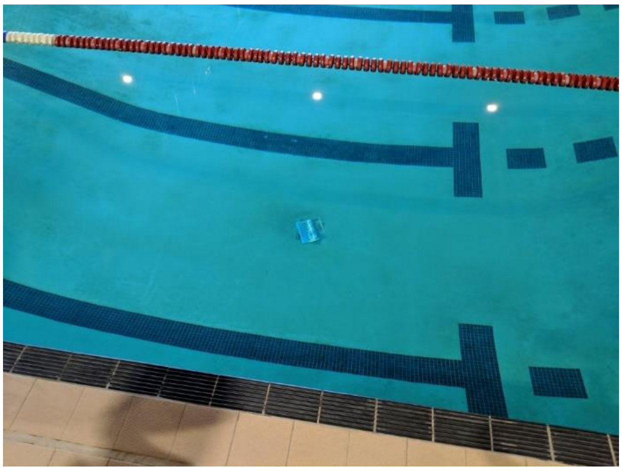
If pool drains are blocked, whatever is causing the blockage will be exposed to the suction force of the circulation pumping system.

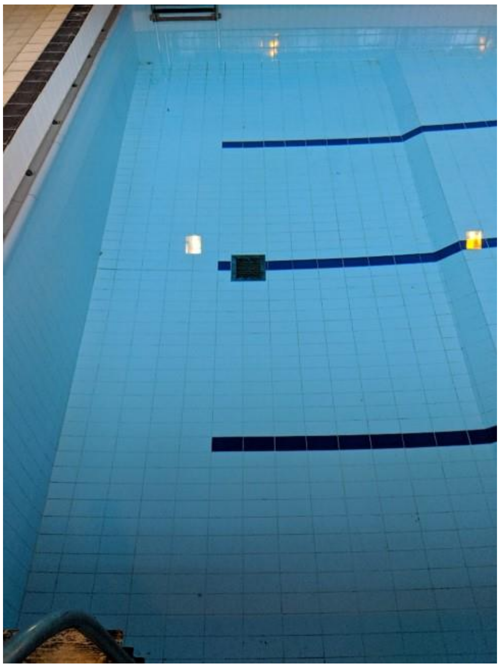
Therefore, removing the blockage without turning off the circulation pump(s) will be impossible.

Suppose the blockage is in the form of a person. In that case, tragic consequences can occur, including drowning and/or disembowelment.

Examples of hazardous outlets

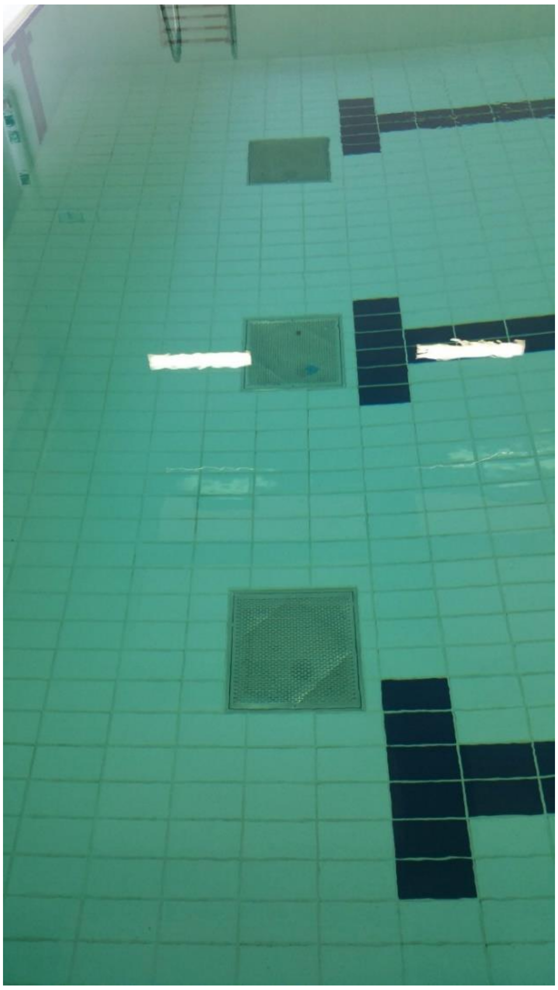






Injuries caused by suction entrapment

Reducing the risk



There are various ways that suction entrapment risk can be reduced:

- Emergency cut-off devices that automatically turn off the suction pumps when an increase in suction force is detected.
- Multiple outlets being fitted so that even if one of the outlets gets covered, the remaining outlets take the increased water flow and prevent a vacuum being created at the blocked outlet (as below).
- Outlets so that it is impossible to cover them and form a seal. This can be achieved via having the grill surface area of sufficient size. It can also be achieved by the use of outlets that are designed to prevent a seal being formed around them when they are covered. These are called anti-vortex drain covers.
- There are also fittings that can be placed over a drain cover that is not an anti-vortex type that will go some way to gaining a similar effect.
- To prevent children from getting fingers/toes trapped in the grill, the apertures should be no wider than 8mm.

Once the above design-based precautions have been considered, other precautions can be implemented such as providing training for all relevant staff regarding the dangers of suction entrapment.

Entanglement hazards

Entanglement hazards are slightly different from entrapment hazards. They involve hair being drawn into the outlet and then entwining on the other side due to the circular motion of the water as it goes through the outlet.

Freeing the hair from the outlet may be impossible, even if the circulation pumps are turned off.

People using spa pools are at an increased risk of suction entanglement because they will be close to an outlet no matter where they are situated within the spa pool.

For this reason, people using spa pools should be advised to tie long hair back and refrain from submerging their head under the water.

Staff responsible for supervising the spa pool should be trained to be aware of the hazards associated with outlets.

Hair Entrapment Test

The PWTAG Code of Practice has a procedure for conducting a test to ensure that there is minimal risk of hair becoming entangled in a swimming pools outlet drain. It can be downloaded at https://www.pwtag.org/download/pwtag-code-of-practice/?wpdmdl=2378&refresh=61483edc46a791632124636 The procedure is at Annex D, towards the end of the document.

Knowledge Test (check answers with tutor)

What is the recommended turnover time (in minutes) for a commercial spa?

Fill in the blank below.

There is a risk of the generation and emission of extremely hazardous chemicals when power to the circulation pumps is cut (deliberately or because of power failure). A system should [ ] be restarted following a failure of the circulation system while there are people in the pool. If there is a concern that there may have been inadvertent mixing of chemicals within the pipework of the circulation system, the fire service should be contacted, and the circulation and chemical dosing systems left stopped.

In a pool with a volume of 50 cubic metres and a flow rate of 100 cubic metres per hour, what would the turnover time be (in minutes)?

Fill in the blank below.

The rate at which the water is circulating around the treatment system is called the ______ rate.

A system should NEVER be restarted following a failure of the circulation system while there are people in the pool. Why?

- There could be a release of hazardous substances into the pool.
- The temperature of the water will be too cold.
- There could be a surge of water that creates a wave effect in the pool.

The amount of time it takes to circulate the pool volume around the treatment system is called what?

- Flow Rate
- Turnover Time
- Circulation Rate

05. Filtration and Coagulation

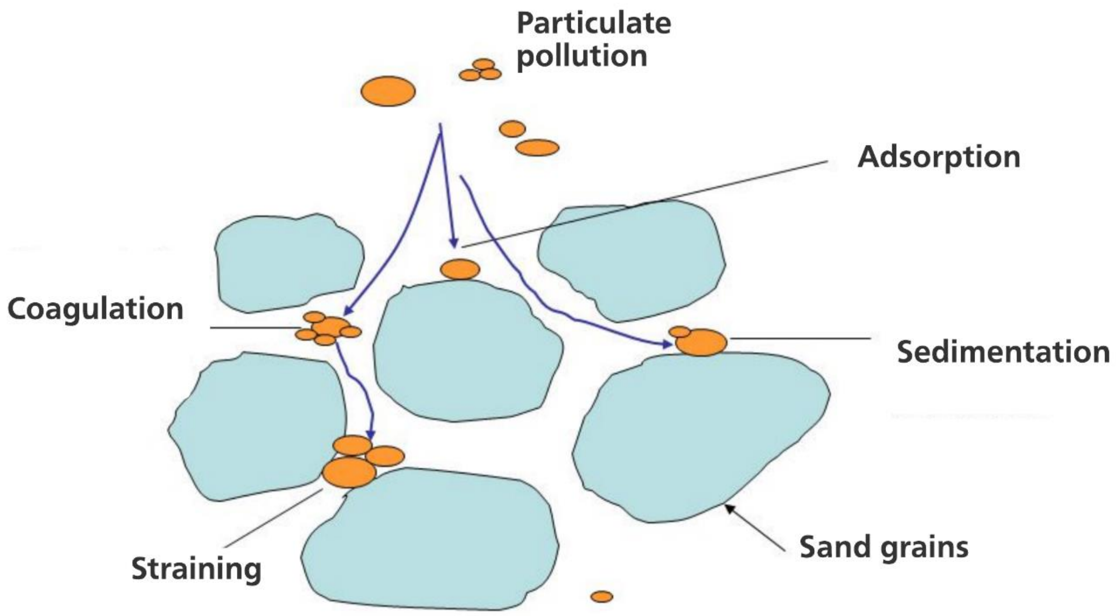
On completion of this lesson, you'll know how filters work, how to maintain them and how to perform backwashes. You'll be able to calculate the filtration rate and compare it to industry standards. You'll know all about coagulation and how it works in conjunction with filtration.

How filtration works

Filtration is relatively simple. Dirty pool water is pumped into the top of the filter (or several filters in large pools). Inside the filter, the water passes through the filter media (usually sand), where all the contaminants and pollution are trapped. Then, the water continues through the remaining components of the pool plant system.
This part of the course will discuss sand filtration primarily, with some summary information at the end about other types of filtering medium.

The 4 processes of filtration

There are 4 main processes happening during effective filtration



Straining

Involves dirty water passing through the filter media and particles of pollution becoming trapped in the small gaps (pores) between the grains of sand because they are too large to pass through.

Adsorption

Very small particles of pollution adhere to the surface of the sand grains. This process is promoted by electrostatic charges within the particles (similar to a balloon 'sticking' to a wall). Once particles begin to adhere to the sand grains, a sticky coating builds up, which promotes further adherence of particles onto the filter media.

Sedimentation

Fine particulate matter settles on the upward-facing surfaces of the sand grains. The process of sedimentation can remove finer particles of pollution than straining. As the amount of sediment increases, the amount of space in between sand grains (pores) decreases. This will cause the velocity of water through the filter to increase. Further sedimentation can then no longer occur and, due to the higher velocity, some sediment could get pushed further down into the filter bed.

Coagulation

Coagulation involves the addition of compounds (usually polyaluminium chloride) that promote the clumping of fine particulates into larger flocs so that they can be more easily separated from the water.

Filter Design, Construction, Inspection and Maintenance

Swimming pool filters are usually designed to a vertical orientation and are made out of various types of material:

- Mild steel
- Stainless steel
- Plastic
- Concrete

The most used is mild steel. The inside surface is lined with either rubber or epoxy paint to protect the vessel from corrosion.

Inspection and Maintenance

Filters that have been appropriately selected and installed should last at least 25 years with proper arrangements in place for inspection and maintenance. On an annual basis, the filters should be opened and inspected by a competent person. For most facilities, this will mean using an external contractor. They should be looking for signs of physical wear or damage to the filter vessel and lining and the condition of the media bed. Issues such as an uneven or shallow bed, mud-balling, crack, fissures etc. should be identified and rectified.

The filter media bed may need to be replaced every 5-10 years, depending on its condition during the routine annual inspections. This provides an opportunity to inspect the underdrains for damage and repair or replace as needed. Deposits of sand on the pool bottom can be a sign of damage to the underdrain system.

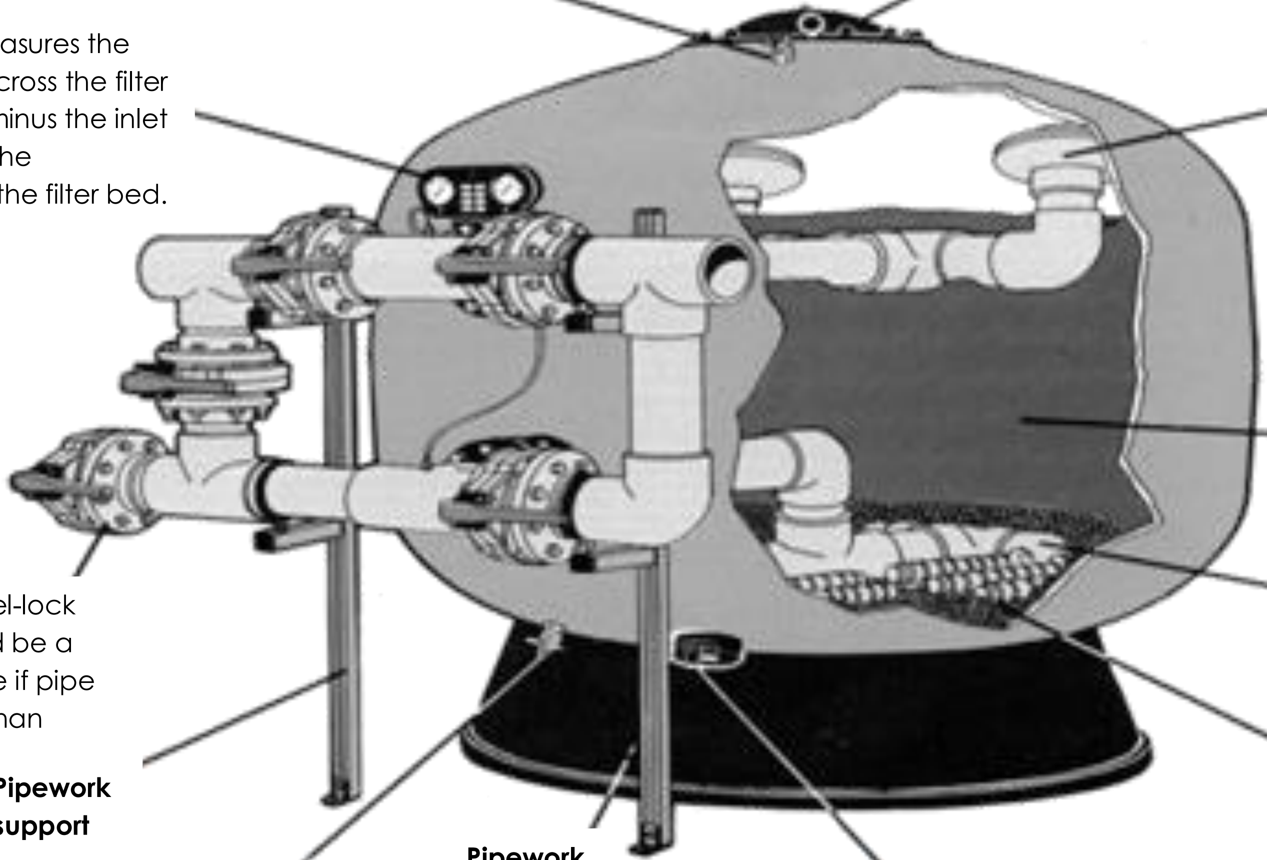
Filter Design and Construction

Air vent – an automatic and manually operated valve should be fitted to each filter.

Access cover – needs to be more than one of these if people are required to enter (one on top, one on the side towards the bottom). 575 – 600mm diameter.

Pressure gauges – measures the pressure differential across the filter bed (outlet pressure minus the inlet pressure). The higher the difference, the dirtier the filter bed.

Diffuser – this distributes the water evenly over the media bed by being pointed up towards the underside of the top of the filter.



Filter media bed – usually silica sand grade 16/30, which gives a grain width of 0.5 – 1.0mm. The depth of the bed should be at least 800mm.

Underdrain manifold

Valve – usually a level-lock butterfly type. Should be a geared butterfly type if pipe diameter is greater than 150mm.

Pipework support

Drain valve

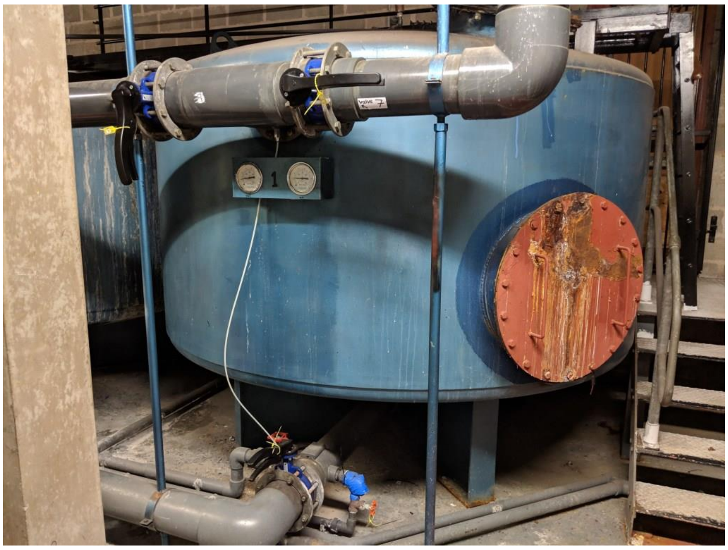
Pipework support

Sand Drain Flange

Underdrains – this collects filtered water via a lateral system of slotted nozzles. The width of the lots will be narrower than the width of the sand grains. The underdrains also distribute the back wash water evenly up through the filter media during a backwash.

Swimming pool filters are usually designed to a vertical orientation and are commonly made out of two types of material.

Steel filters have a life expectancy of **30 years** – achievable if the filter lining is maintained. The lining would typically be replaced every 5-10 years at the point when the media is being replaced. Most manufacturers provide a minimum 5-year warranty on the lining.



Glass fibre-reinforced polyester resin (GRP) filters are produced from a mould, with support skirt added and polyester flanged connections for ancillaries.
Good, industrial-quality GRP filters are supplied with a manufacturer's warranty of 10 years. However, based on experience and quality, life expectancy may vary between **10 and 40 years**. So extreme care should be exercised in selecting only the best quality GRP filters for industrial applications. In addition, the life expectancy of GRP filters can be reduced if they are operated outside the vessel specification – for example, pressurising beyond the vessel's stated operating or test pressures.

Filter media

The most common type of filter media is sand. The sand specification is commonly 16/30 dried silica sand.

The media in a filter is typically multi-layered, with a larger diameter (typically 6-10mm) support material at the bottom and the finer grade material above. On single-grade media beds, the finer grade media bed depth ranges between 1.0m and 1.2m and the support layer is 15-20% of the bed depth. On multi-grade beds, the media is typically graded in 5 or 6 layers between 10mm gravel and finer sand/glass as described above. Over a period of time in operation, the media can deteriorate and should be regularly inspected (at least annually) to ensure optimum filtration efficiency.

Other media types

Cartridge filters	These types of filter use a membrane made of polyester of similar material that is corrugated to increase the overall filtering surface area and place inside a plastic cartridge that is fitted onto the circulation line. These types of filters are not recommended for use in commercial pools as they do not have the same filtering efficiency as sand filters.
Diatomaceous earth	This is a type of filtering medium which is made up of the fossilised remains of microscopic marine life (diatoms). The fossilised remains are mined and processed into a fine off-white powder. The use of this type of filtering medium is not recommended for commercial use as inhalation of the dust given off can be hazardous to health.
Glass	Glass can be recycled to be used as a filtering medium by processing it to appear and function much like sand. Pool operators are advised to be wary of claims of additional benefits (over sand) as PWTAG have not found reliable evidence to support these claims.
Carbon	Carbon filtration is used primarily for the removal of ozone in systems that use ozone as a disinfectant. It also removes chlorine, which makes the filter media vulnerable to infection with pseudomonas aeruginosa.
Membrane	These are filters that force the water through a membrane made of either ceramic, glass, carbon, metal. There are various levels of filtration that can be achieved; microfiltration removes bacteria, ultrafiltration removes viruses also, nanofiltration removes sugars and pesticides also and reverse osmosis removes silts also. Membrane filters take up less floor space than sand filters and there is the possibility that they could be used to 'recycle' backwash water, so instead of discharging it to drainage, it could be recirculated back into the system, thus providing potential costs savings.
Zeolite	This is a mineral substance that has been marketed as being effective at removing ammonia from the pool water. The Pool Water Treatment Advisory Group (PWTAG) have examined the evidence and have concluded that there is no proven case for using it.

Filtration Rate

Filtration rate vs. flow rate

The filtration rate is the rate at which the pool water moves down through the filter during operation.

It is not to be confused with the flow rate, the rate at which water moves through the entire circulation system.

"Is the filtration rate important – do I need to know it?"	Yes, and yes! Filtration rate has an effect on how well the filter does its job (filter contaminants out of the water), so pool operators need to know it so that they can assess whether the filtration rate of their filters meets industry guidelines (covered later).

Calculating the filtration rate

The filtration rate is calculated by dividing the flow rate by the filtration surface area. So, you need to know the flow rate before working out the filtration rate.

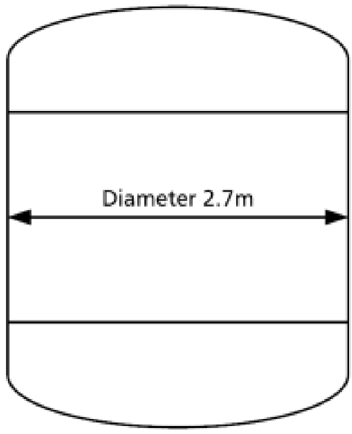
Hopefully, you already have a flow rate meter fitted onto the circulation pipework in your plant room to tell you the flow rate. If you do not have one, it is highly recommended that you get one as soon as possible. Without one, it will be difficult to calculate the turnover time, never mind the filtration rate!

As for the surface area of the filter, you may be able to obtain this information from an information panel stuck onto the side of the filter. See the image for an example. If there's no sticker, follow the instructions below.

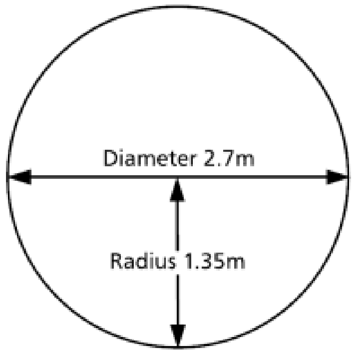
The filtration rate is the rate (in metres per hour) at which the pool water moves down through the filter during normal operation. It is not to be confused with the flow rate, which is the rate (in cubic metres per hour) at which water is moving through the circulation system.

The filtration rate is calculated by dividing the flow rate by the surface area of the filter. For example:

Circulation Rate:	100 cubic metres per hour
Filter Surface Area:	5.72 metres squared
Filtration Rate:	100m3 / 5.72m2 = 17.48m3/m2/hr



You may already have a flow rate meter fitted onto the circulation pipework in your plant room to tell you what the flow rate is. If you do not have one fitted, it is highly recommended that you get one fitted as soon as possible as it will be difficult to calculate the turnover time and filtration rate without having the key piece of data that a flow rate meter provides.



If you are trying to calculate your filtration rate, but don't know the surface area of the filter, you can easily calculate what the filter surface area is by using the formula: $r^2 \times \pi$. This formula means the radius squared multiplied by pi. See below for an example using a filter that is 2.7 metres wide:

Width of filter: diameter)	2.7 metres (this is also the	
Radius:	2.7m / 2	= 1.35m
Radius Squared:	1.35m x 1.35m	= 1.82 m2
Surface Area:	1.82m x 3.14 (pi)	= 5.72 m 2

There are three categories of filtration rate, set out below:

Low Rate: up to 10 m3/m2/hr	very good filtration, but requires a very large surface area
Medium Rate: 10 - 25 m3/m2/hr	recommended for public pools
High Rate: 25 - 50 m3/m2/hr	recommended for small domestic pools only because this rate is too fast to deal with pollution in public pools

Backwashing

Purpose of backwashing

The filter's job is to trap as much pollution as possible as water from the pool is pushed through the filter media. As long as the filters are working correctly, over time, more and more of this pollution will build up within the filter media. This accumulated pollution must be cleared away from inside the filter(s) at regular intervals. Backwashing is the process of cleaning the filters.

Backwashing involves reversing the flow of water through the filter. The upward pressure of the water causes the sand bed to break up and 'fluidise'. This dislodges the pollution, which usually goes to drainage (NOT back into the swimming pool!).

When to backwash

If you have the filter manufacturer's instructions, refer to those, as they will inform you how often a backwash needs to occur.

As the filter does its job and collects all the pollution and contaminants from the pool, it starts to become congested. This process is helpful towards the beginning of the cycle as it causes narrower gaps between sand grains (known as pores). This means that the filter will be capable of trapping smaller particles. This process is known as 'filter ripening'. As this process is happening, the resistance to flow encountered by the pool water as it enters the top of the filter will increase. At the same time, the force at which the water comes out of the filter at the bottom decreases.

It's a bit like when you get a kink in a hosepipe; you'll only get a trickle out of the end of the hose, and the pressure will build up behind the kink.

There are usually pressure gauges on the inlet and outlet of a filter; their job is to tell the pool plant operator what the pressure differential (or head loss) is. As the pressure increases at the inlet, the needle on the inlet gauge will move up. At the same time, as the pressure at the outlet decreases, the needle on the outlet pressure gauge will move down. By reading the values at the gauges and comparing them, you can work out the pressure differential across the filter bed. As a rough guide, when this pressure differential reaches 0.4bar, it's time to do a backwash.

What usually works better from an operational point of view is to do a backwash every week, keep an eye on the pressure differential, and review the policy if needed.

The pressure gauges must be regularly maintained and calibrated to ensure that the information provided is accurate.

If your filter only has one pressure gauge, like the one shown in the image, the pressure shown on the gauge is the inlet pressure. Use the coloured markings if there are any, i.e., a backwash would be required on the filter shown in the picture when the pressure reached 1.1 bar.

If there are no coloured markings, note the pressure immediately following a backwash. This is your ‘clean’ filter pressure. Once it goes 0.2 – 0.5 bar above that – it’s time for a backwash.

Note: PWTAG recommends backwashing commercial spa pool filters daily.

“Are we ok to do backwashes while the pool is in use?”	No. During a backwash, there is no water treatment happening. That alone should be reason enough, but there are a couple of other things to consider. First, there is always the chance that something could go wrong, and that filter media or chemical by-products will be released into the pool. Another thing is that after a backwash, the filter needs time to re-ripen (more on that in the next topic).

How to do a backwash

There should be a step-by-step guide in the Normal Operating Procedure (NOP) or systems of work etc. to guide you through it. See below for a simplified example.

1. Switch off chemical dosing and circulation.

2. Adjust valves so that the pool water goes into the filter at bottom and out at the top, and from there to drains.

3. Switch circulation back on and leave running until the pool water is visibly clear.

4. Switch circulation off and adjust valves so that the pool water goes in at the top and out at the bottom, but still runs to drains (this is called the 'rinse' and serves to re-compact the media bed and settle it back down following the backwash).

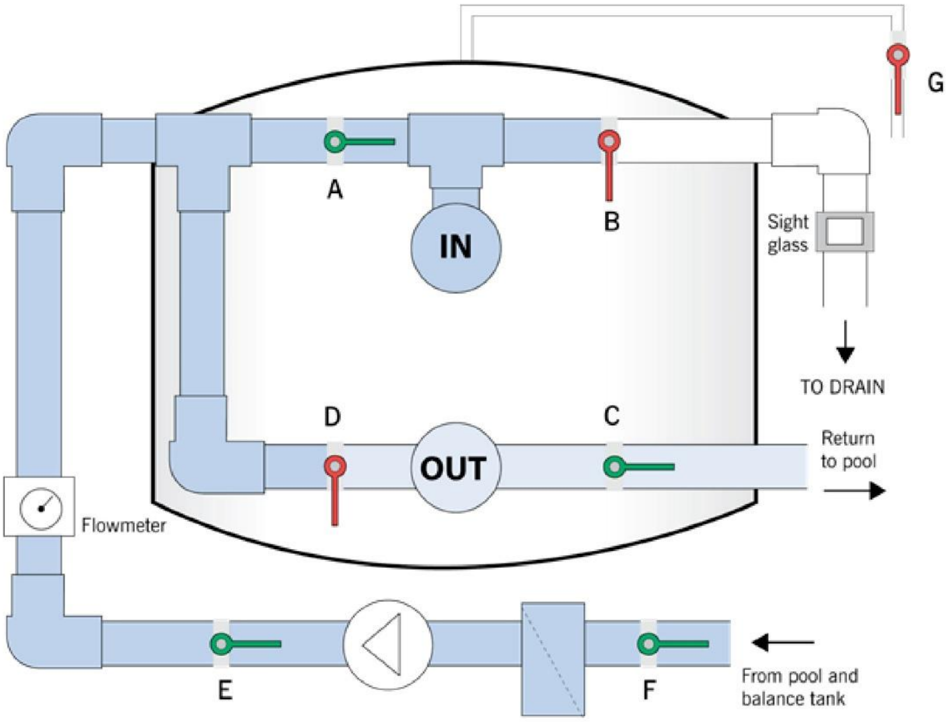
5. Switch circulation back on and leave running until the water is visibly clear.

6. Switch circulation off and adjust valves so that the pool water goes in at the top and out at the bottom, but this time returns to the pool.

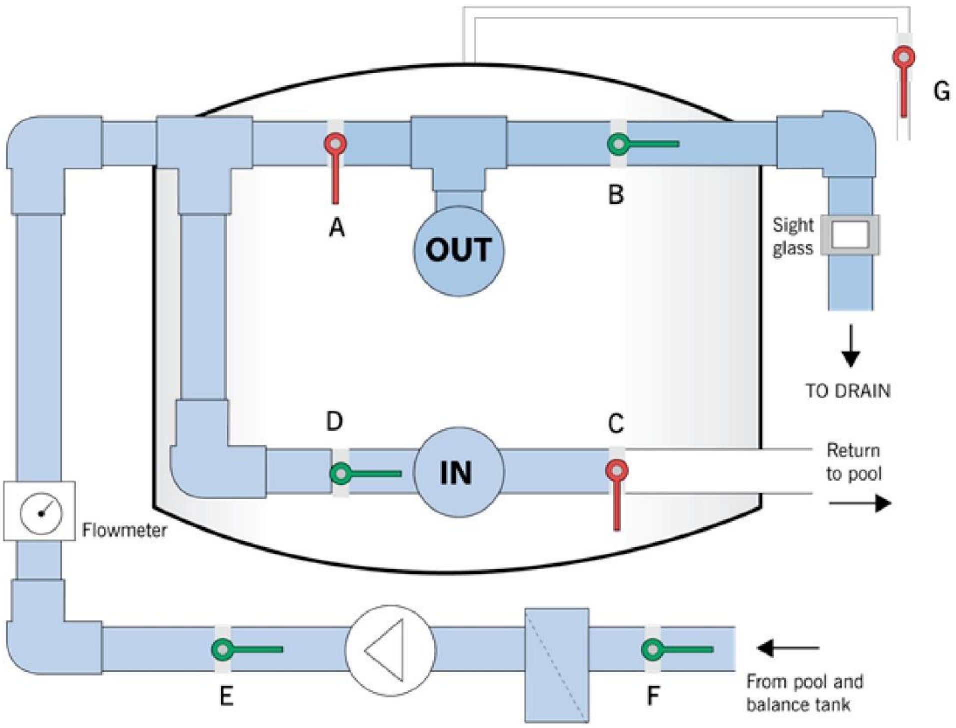
7. Switch the circulation and chemical dosing back on.

8. Purge the system of trapped air by opening the air release valve at the top of the filter and 'bleeding' the air out.

Normal Filtration Configuration



Backwash Configuration



Backwash rate and fluidisation

A sand bed can become quite compacted during filtration due to gravity and the downward pressure of the water as it is pumped through the filter.
The backwash rate must be fast enough to overcome this compaction and expand and fluidise the sand bed. Otherwise, the backwash will be unsuccessful, and pollution will remain trapped in the sand bed.

PWTAG recommend a backwash rate of **30m3/m2/hr**.

The backwash rate is calculated the same way as the filtration rate; note the flow rate during a backwash and divide by the filtration area of the filter(s) being backwashed. Or use the calculator.

Sometimes, usually in larger filters, an air compressor is used to force air through the sand bed prior to backwashing. This is called air scouring. More detail in the drop down.

Air Scouring

Air scouring is a process of forcing air up through a filter bed prior to backwash to expand the filter media and loosen dirt particles. An air scour rate of about 32m/h is desirable to aid backwashing. Not all pool plant systems have an air scour system as part of the original installation, but they are possible to retrofit and pool operators should consider this as an option, especially if they suspect that the pumps are struggling to achieve sufficient backwash flow rate velocity.

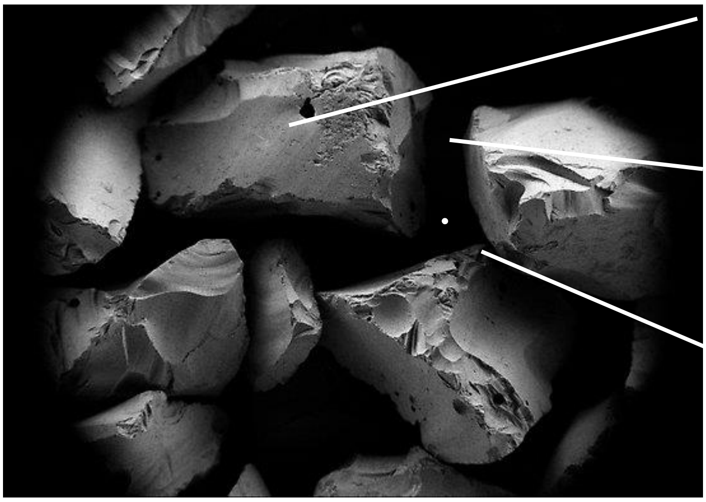
Coagulation

Filtration alone is not sufficient to trap very small particulate pollution. In swimming pool filters, the size of the sand grains is usually 0.5 - 1.0mm. This results in a pore size of approx. 50 – 70 microns (1mm = 1000microns).

Anything too big to pass through the pores will become trapped, anything smaller may pass through unless they settle on the upper-facing surface of a sand grain, or they are stick to the surface of a sand grain via adsorption.

If you consider that the size of cryptosporidia oocysts is approximately 3 – 5 microns, you will realise that sand filtration on its own will not be adequate to remove it. This is why it's very important to pay close attention to the process of coagulation, which clumps small particles of pollution together to form what are known as flocs.

This process of coagulation, combined with the fact that filtration is a progressive process (more and more pollution will be removed each time the water passes through the filter) means that it is possible to remove particles smaller than 50 – 70 microns, in fact there is no specific bottom limit to the size of particle that can be removed.



Typical size of filter sand 0.5 – 1.00mm

Average pore size 50 – 70 microns

The white dot is much bigger than a cryptosporidia oocyst (which is 3 – 5 microns)

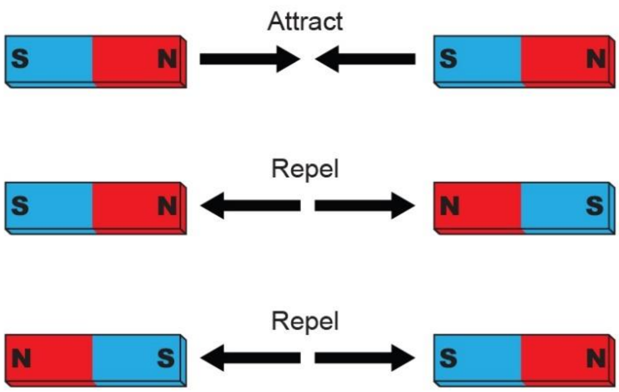
As the filter begins to trap particles, the size of the pores decreases. This is known as 'filter ripening'. When the filter is fully ripened, it will be capable of straining particles the size of around 5 - 10 microns.

The size of cryptosporidium cysts are about 3 - 5 microns, bacteria is around 1 - 5 microns, and colloidal matter can be as small as 0.1 micron, so as you can see, even with a ripened filter, some of the pollution is too small and will pass through the filter.

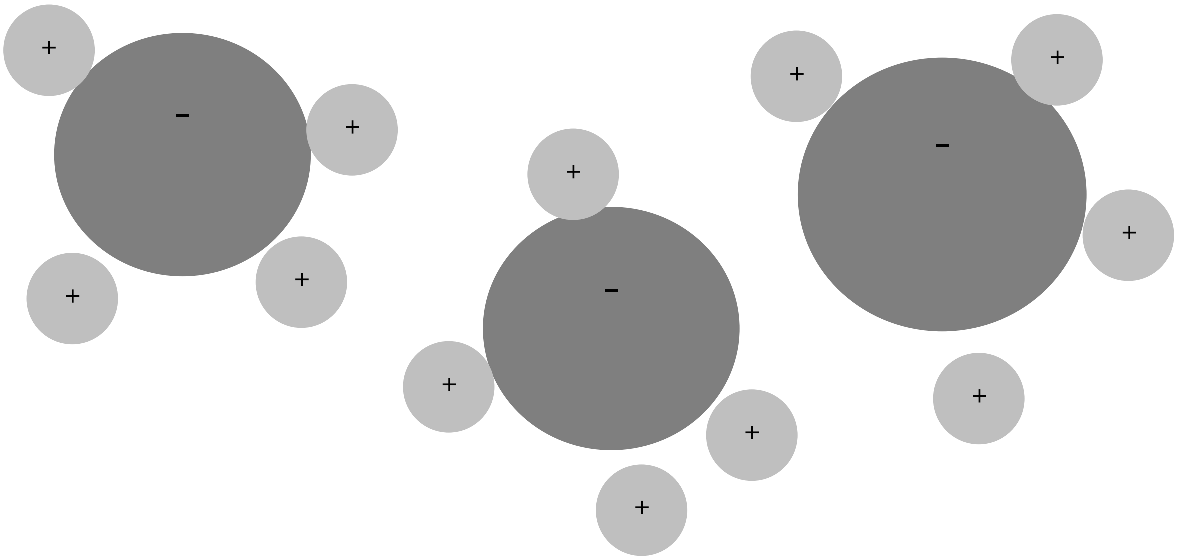
Cryptosporidia is not going to be killed by the chlorine in the pool, so it is essential that it is retained within the filter. A coagulant is required, which works by causing the small particles suspended in the pool water to bind together to form what are known as flocs. The flocs are typically 20 - 50 microns, so will be large enough to become trapped in the filter. The most common coagulants used in swimming pool water treatment are:

- Polyaluminium Chloride (PAC)
- Polyaluminium Sulpho-silicate (PASS)
- Aluminium Sulphate (Kibbled Alum)
- Sodium Aluminate

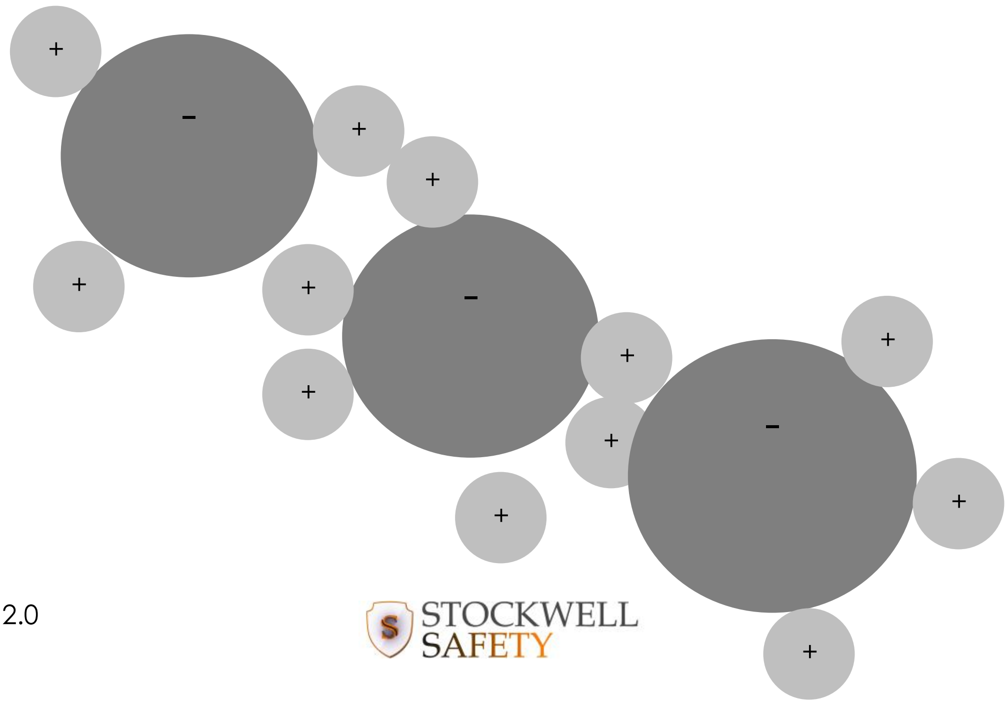
Usually, very small particles tend to attract together when they get close enough to each other, but this is not the case in pool water, where the opposite is true, i.e., the tiny particles of pollution in pool water will tend to repel, rather than attract. The cause of this repulsion is the fact that the suspended particles carry a positive electrostatic charge. If you imagine having two magnets and putting the positive ends together, you will be able to appreciate this phenomenon.



This is a bit like what's happening with all of the tiny particulate pollution in the pool water. What needs to happen in order to get it all starting to attract together is a balance between the positive and negative charge…opposites attract! This is where coagulation comes in. Coagulation involves adding a chemical that has an abundance of positive charges. In most pools this chemical goes by the name of Polyaluminium Chloride, or PAC for short. It's a thick, viscous liquid, with a pH of around 3 (very acidic), that contains aluminium ions that are positively charged. When the PAC is injected into the circulation pipework (between the pump(s) and the filter(s), it mixes with the pool water and starts to surround the negatively charged particulate matter.



Now that the negatively charged pollution is surrounded by positively charged aluminium ions, things start to attract and stick together. Now imagine putting the positive end of a magnet next to the negative end of another magnet and you will appreciate what is happening in the pool water. As tiny particles come together and stick to each other, larger 'clumps' of material begin to be formed. There are known as 'flocs'. This is the process of coagulation.



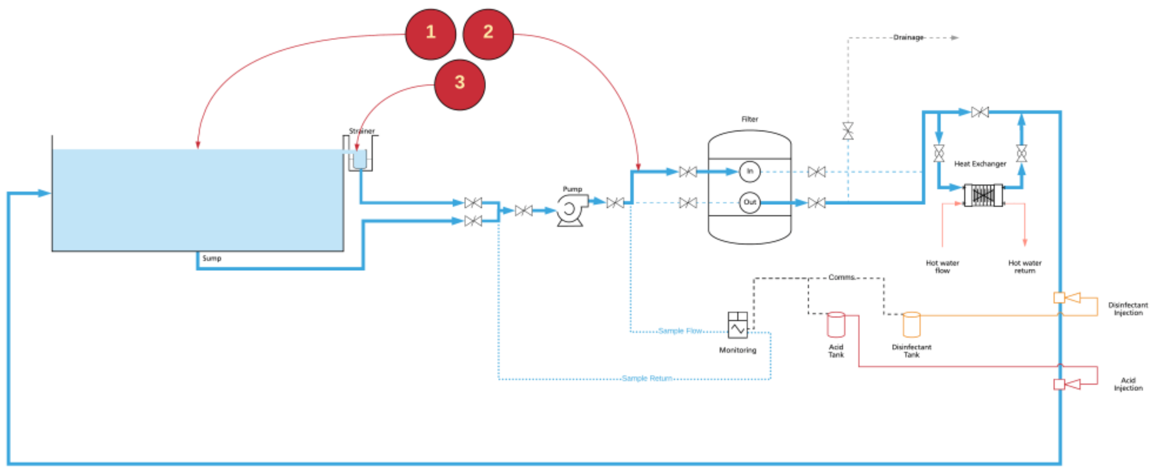
Selection and dosing of coagulants

The dosing of coagulants is a critical factor. Too little and there won't be adequate coagulation taking place, too much and there will be an over-abundance of positively charged aluminium ions. Remember that there needs to be a balance between positive and negative to get the attraction to take place.

The recommended coagulant chemical to use in the treatment of swimming pool water is ***Polyaluminium Chloride***, or PAC for short. It's a thick, viscous liquid, with a pH of around 3 (acidic). When PAC is injected into the circulation pipework (between the pump(s) and the filter(s)), it mixes with the pool water and starts to surround the negatively charged particulate pollution.

"We put scoops of alum into the skimmer baskets at our place. Is that OK?"	No. An alternate chemical that used to be used quite widely was aluminium sulphate (often referred to as kibbled alum, or alum). The alum was supplied in solid form and was typically 'slug-dosed' into the strainer baskets on poolside (slug-dosing is where a fairly large quantity is added in one go). **This practice is no longer recommended** (although many pools are still using this method, unaware of the disadvantages).

Polyaluminium should be injected into the main circulation pipework, prior to the filter(s). In order to allow the maximum amount of contact time, the injection point should be as far upstream of the filter(s) as possible, but no further than the sample draw-off point for the automatic monitoring equipment.



Look at the schematic. Which of the 3 options is the correct point for PAC injection? Discuss the options with your tutor.

Flocculation

The flocs that are formed as part of the coagulation process themselves come together in the headspace of the filter (the space between the top of the filter media bed and the top of the filter vessel) and eventually produce a floc that is visible to the naked eye and forms a gel-like layer on top of the filter media. Flocculation takes longer to occur than coagulation and in a typical pool plant system there will not be enough time for extended flocculation to take place.

Some final points…

- Coagulation is much less effective in high rate filters than in medium rate filters.
- It's much less effective at higher pH levels, try to keep the pH in the 7.0 – 7.2 range.
- It's much less effective at low levels of total alkalinity (covered later), keep TA in the 80 – 200 mg/l range.

Regenerative media filters

Regenerative media filters remove particles from dirty pool water by forcing the water through thin layers of powdery filter material that capture the unwanted dirt, oils, and other materials suspended in pool water.

All regenerative media filters use a powdery coating material such as diatomaceous earth or perlite to filter unwanted elements from the swimming pool water. Diatomaceous earth (DE) is a fossilized material that is mined and refined for use as a filter medium. Perlite is derived from volcanic rock that is superheated to create the powdery substance used in filtration. Both of these substances consist of small particles that have large surface areas, in relation to their overall size, to capture the unwanted materials in pool water. Please note that wherever perlite is mentioned in this article, DE can be substituted. Perlite however, is the material recommended for use with most modern regenerative media filters.

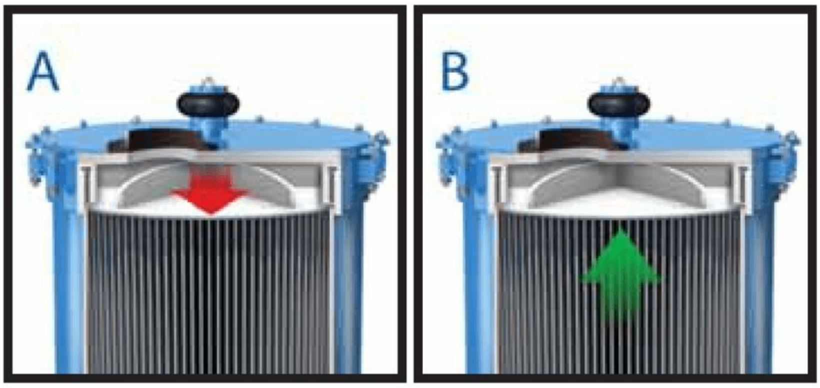
This type of filter reduces the amount of backwash water associated with sand filter operation. Instead of backwashing, it is programmed to automatically "bump" to regenerate the fine-grade perlite media for a fresh start.

The "Flex Tubes" (aka "wands" can be seen through the viewing glass in the side of the filter.

Eventually the filter will become saturated with trapped dirt and will require media discharge and replacement. Depending on bather load, the life cycle of the media averages around four weeks.

The Defender filter is programmed to automatically "bump" on a daily basis to regenerate the media coating of the "Flex Tubes".

As the bump tire deflates (A), the tube sheet lowers to loosen the media and trapped debris. The re-inflation of the bump tire (B) raises the tube sheet and forces water into the "Flex Tubes", gently expanding them to fully release all material. This bump cycle pulses ten times to ensure the entire cleaning process.



At the completion of the bump cycle, the Defender filter will automatically pre-coat the "Flex Tubes" and recommence the filter cycle. The "Bump" is a vital function in order to achieve superior filtration and to make the most out of every filter cycle.

PWTAG Advice on pre-coat filters

Non-regenerative (or pre-coat) filters have been used for some time – more abroad than in the UK. They can be effective, and take up less space than traditional sand filters, but their practical limitations have made it impossible for PWTAG to recommend them on large, busy public pools. They demand more skill from operators than sand filters.

The powdery filter coating is not replaced; instead, it is shaken down from the nylon filter wands at intervals (a process known as bumping) and allowed to reinstate. Filter media is replaced only after many such operations (commonly about every six weeks). It is important that operators use only the grade of filter medium recommended by the manufacturer. RMF installations may also have backup from UV and reverse osmosis (as may conventional filters).

Two immediate advantages are sometimes claimed over traditional sand filters: that they take up less floor space, and that significantly less water is used. The first is demonstrably true – although their use in a new pool means that any subsequent choice for replacement would be restricted to similar filters as there is unlikely to be enough floor space for conventional sand filters. They are also taller than sand filters. RMF filters are being promoted for use in any pools – including large busy ones.

The water saving issue is discussed here, as are other considerations.

Effectiveness

Pools with RMFs can provide good quality water, but like any filter there can be problems. There are also issues about the principle of the filters' operation.

- The wands may not always completely re-coat after bumping. There remains a very significant filtration area which is covered, and the effect of the gaps in cover is uncertain. But there must be a possibility that pollution, including microorganisms, would pass through.
- The build-up of media on the filter wands can bridge between wands. There is some disagreement, even between manufacturers, about how much of a problem this is, but any bridging would reduce the effective filter area.
- The build-up of grease on wands will inhibit the adhesion of filter media (as might hardness scale and other chemical deposits). So wands have to be cleaned and degreased as necessary – sometimes as often as every six weeks. This may require an alkali wash, taking several hours, during which time the filter is out of action. High-pressure hosing is an alternative, although health and safety issues would need to be addressed.
- Filtered material, including microorganisms, remains in the filter and forms part of the mainly filter media mix that re-coats wands during bumping. Organic matter held on the filters has the potential to release disinfection byproducts into the pool water. Sand filters also retain such materials, but they are routinely backwashed to waste at least once a week. RMFs, by contrast, retain these materials until the medium is replaced (perhaps after six weeks).

- Microbiological tests are only a monthly snapshot of pool hygiene. Results PWTAG has obtained from pools with RMFs have been patchy, as they can be with any pool. In at least one pool, poor results were associated with gaps in filter media coverage.
- Replacement of wands and general refurbishment need to be considered carefully. Such issues are more challenging than with sand filters.

Water savings

PWTAG is concerned that some pool operators believe the use of RMFs will result in cost savings associated with water and heat because there is no backwashing. But water replacement (dilution) in swimming pools is not only to replace backwash water but also to reduce the build-up of bather pollutants and chemical breakdown products from everyday water treatment processes. PWTAG recommends a water replacement rate for this purpose of 30 litres per bather irrespective of the filter type. This is widely accepted as important for good pool water treatment: without adequate dilution dissolved solids and chloramines can build up. Pools with regenerative media filters have been found to have total dissolved solid (TDS) levels very much more than 1,000mg/l above source water because dilution was being neglected. Chloramines, too, have been a problem in some cases.

Knowledge Test (check answers with tutor)

How often should the filter media be changed in a commercial swimming pool sand filter?

- ○ Every 5-10 years
- ○ Every 25 years
- ○ Every 12 months

Fill in the blanks.

1. ______ – Very small particles of pollution adhere to the surface of the sand grains. This process is promoted by electrostatic charges within the particles (similar to a balloon 'sticking' to a wall). Once particles begin to adhere to the sand grains, a sticky coating builds up, which promotes further adherence of particles onto the filter media.

2. ______ – Fine particulate matter settles on the upward-facing surfaces of the sand grains. The process can remove very fine particles of pollution. As the amount of sediment increases, the amount of space in between sand grains (pores) decreases. This will cause the velocity of water through the filter to increase. Further sedimentation can then no longer

occur and, due to the higher velocity, some sediment could get pushed further down into the filter bed.

3. ☐ – Involves dirty water passing through the filter media and particles of pollution becoming trapped in the small gaps (pores) between the grains of sand because they are too large to pass through.

4. ☐ – Involves the addition of compounds (usually polyaluminium chloride) that promote the clumping of fine particulates into larger flocs so that they can be more easily separated from the water.

What is the recommended filtration rate for commercial swimming pool sand filters?

- ○ up to 10 m3/m2/hr
- ○ 10 – 25 m3/m2/hr
- ○ 25 – 50 m3/m2/hr

What is the name of the organism that is not killed by typical swimming pool chlorine levels?

How is the filtration rate calculated?

- ○ Divide the flow rate by the turnover time.
- ○ Divide the pool volume by the flow rate.
- ○ Divide the flow rate by the filtration surface area.

What is the recommended backwash rate for a commercial swimming pool sand filter?

- ○ 10m3/m2/hr

- 30m3/m2/hr
- 5m3/m2/hr

Where is the correct dosing point for polyaluminium chloride coagulant?

- Prior to the filter(s)
- Prior to the heat exchanger
- Prior to the pump(s)

Why is important that the backwash rate is fast enough?

- So that a sufficient amount of pollution is removed from the pool water.
- So that a sufficient volume of fresh top-up water goes into the pool.
- It needs to be sufficient to expand and fluidise the sand bed.

What is the purpose of the pressure gauges fitted to most types of commercial swimming pool filter?

- Helps to determine the turnover rate.
- Indicates the filtration rate.
- Indicates the difference between the inlet pressure and the outlet pressure, which helps to determine backwash frequency.

Number the steps in the backwash procedure in the correct order.

Switch circulation off and adjust valves so that the pool water goes in at the top and out at the bottom, but still runs to drains (this is called the 'rinse' and serves to re-compact the media bed and settle it back down following the backwash).

Switch circulation back on and leave running until the pool water running through the sight glass is visibly clear.

Adjust valves so that the pool water goes into the filter at bottom and out at the top, and from there to drains.

Switch circulation off and adjust valves so that the pool water goes in at the top and out at the bottom, but this time returns to the pool.

Switch circulation back on for a second time and leave running until the pool water running through the sight glass is visibly clear.

Switch off chemical dosing and circulation.

Switch the circulation and chemical dosing back on.

Purge the system of trapped air by opening the air release valve at the top of the filter and 'bleeding' the air out.

06. Disinfection and pH Control

On completion of this lesson, you'll understand the chemical reactions involved with disinfection. You'll be able to influence these reactions to ensure that effective disinfection occurs without unwanted chemical by-products accumulating to harmful levels.

Primary Disinfection

How disinfection works

Regarding swimming pools, the term disinfection refers to the methods used to remove the risk of infection in people who come into contact with the pool water. The ways by which disinfection is achieved in a swimming pool can be a combination of physical (e.g. filtration) and chemical (e.g. chlorine).

In all pools, the water must contain sufficient concentrations of a chemical disinfectant at all times. The purpose of this chemical disinfectant is to act as a biocide that will kill germs. This aims to maintain a level of chemical disinfectant in the pool water and is referred to as primary disinfection.

Most disinfectants act as biocides via their ability to oxidise organic compounds.

Two factors influence the effectiveness of chemical disinfection:

1. The amount of disinfectant in the pool water (free chlorine residual)
2. The time that the disinfectant will be in the pool water (contact time)

When these two factors are multiplied, the result is the exposure value.

Types of Disinfectant

Calcium hypochlorite

- dry product (pellets or granules)
- 65 - 70% chlorine
- pH of approx 10 - 11
- recommended for soft water areas
- long storage time

This is a dry product and typically gets supplied as pellets or granules. It often goes by the name of HTH, but this is a common brand name, not the name of the chemical. It gets mixed with water to form a solution and then gets injected into the circulation pipework either before or after the filters (systems that include non-residual disinfection, such as ultra violet or ozone will always have their chlorine dosed after the non-residual disinfection point of contact, which will always be after the filters).

As the name suggests, calcium hypochlorite contains quite a lot of calcium compared to sodium hypochlorite. Therefore, it is usually not recommended to use this type of product in hard water areas, as there will already be a lot of calcium in the source water. Because of the high calcium content, calcium hypochlorite creates a rather 'gritty' solution when mixed with water. This grit settles out of solution on the bottom of the tank and can also clog up the feed lines and injector points etc.

Calcium hypochlorite is a dry and relatively stable compound of chlorine, calcium and oxygen. It must be kept dry and free from contact with all organic materials including paper products, oil and oil products, detergents, cleaning fluids and acids. Contact with organic materials, including isocyanurates and other chemicals, causes a heat reaction, and can lead to explosion, fire and the emission of toxic fumes. Contact with acids liberates toxic chlorine gas.

Spillage should be avoided, as mixture with other chemicals already on the floor or other surfaces could also cause these problems. It should be stored in sealed containers, off wet floors and away from pipes and hot water heaters.

There must be 'no smoking' signs in the storage area where this chemical is kept. Suitable personal protection should be used when handling and the provision of an emergency shower considered in large installations.

Sodium hypochlorite

- wet product (liquid)
- 10 - 15% chlorine
- pH of approx 13
- recommended for hard water areas
- short storage time

This is a liquid product and is very similar in appearance and odour as ordinary household bleach. It usually gets delivered in plastic carboys and is then transferred to the day tank(s) via a hand pump. In larger facilities it gets delivered via a tanker that fills up a bulk tank at a filler point and then the product is transferred to the day tank.

Sodium hypochlorite is the recommended disinfectant for areas that have hard source water. If calcium hypochlorite was used in a hard water area, the result would be calcium hardness levels that are too high, leading to problems with scaling.

As sodium hypochlorite is a liquid; if a liquid acid is used with it, there should be safeguards to prevent any confusion between them. The inadvertent direct mixing of an acid with sodium hypochlorite will liberate toxic chlorine gas and the system should be designed to prevent this taking place.

Carbon dioxide (or carbonic acid) may be used as the acid in some pools. The system works by metering carbon dioxide gas into the water recirculation system. It works best where the total alkalinity of the water supply is less than 150 mg/l of $CaCO_3$ and where there are no water features such as wave machines or fountains which expel the carbon dioxide from the water. It has the advantage that, unlike other liquid acid systems, there is no possibility of the accidental generation of chlorine gas.

Storage of liquid carbon dioxide (particularly in a relatively confined space) does, however, carry its own risk: displacement of oxygen, leading to asphyxiation; and toxicity at high concentrations. Cylinders of carbon dioxide should be stored outside buildings in well-ventilated areas.

Sodium hypochlorite can also react vigorously with oxidising materials such as chlorinated isocyanurates. Suitable personal protective equipment should be used when handling and there should be ready access to an emergency shower where bulk tanks are used.

Electrolytic generation of sodium hypochlorite

Some sites have a system whereby they create their own sodium hypochlorite. This is achieved by making a brine solution (water + salt) and then passing this solution through an electrolysis unit that converts a proportion of the brine solution into sodium hypochlorite. The sodium hypochlorite gets transferred to a day tanks and gets progressively stronger with each pass of brine solution through the electrolysis unit. The big advantage to this system is that staff are not required to handle the sodium hypochlorite. All they need to handle is the salt when they top up the brine tank. Some of the disadvantages of the system are that it produces hydrogen gas, which is explosive and the equipment required can be expensive.

Hydrogen gas released during the electrolytic process should be vented safely into the open air. Selection and siting of any electrical equipment associated with the electrolytic generator requires careful consideration.

Maintenance of electrical equipment is likely to be a job for specialist staff, but staff should be aware of the general hazards of using electrical equipment near these processes.

Chlorinated isocyanurates

Chlorine is broken down by ultraviolet light in sunlight. Therefore, chlorine gets depleted very quickly when the sun shines onto an outdoor pool (or through some types of glazing onto indoor pools). This means that algae can proliferate and turn the water green.

Cyanuric acid stabilises the chlorine by binding with hypochlorous acid (the disinfectant element of chlorine). This makes it more resistant to degradation by UV. However, the drawback is that it also makes the hypochlorous acid less effective as a disinfectant. Therefore, higher free chlorine levels must be maintained when using cyanuric acid (2.5 – 5.0 mg/l).

Dosing the correct amount of cyanuric acid is critical. Too little and you won't stabilise the chlorine enough; too much and you will over-stabilise, making the chlorine ineffective. Cyanuric acid levels should be kept below 200 mg/l, with the ideal range being 50 – 150 mg/l. The most effective way to control cyanuric acid levels is through dilution with fresh water.

It is possible to simply add some cyanuric acid to the circulation system in conjunction with sodium/calcium hypochlorite (but dosed separately – never allow them to mix). Many outdoor pool operators prefer to add a chemical that contains both the chlorine and the cyanuric acid. There are two chemicals on the market:

- **Dichloroisocyanuric acid (dichlor).** 55% available chlorine. Comes as a white powder. pH is around 6.5 (slightly acidic).
- **Trichloroisocyanuric acid (trichlor).** 90% available chlorine. Comes as white powder, granules or tablet. pH is around 3.0 (fairly strong acid).

Although stabilised chlorine looks very similar to calcium hypochlorite, these two chemicals will explode if mixed!

We do not recommend the use of chlorinated isocyanurates in commercial pools, unless there is the need to stabilise the chlorine against UV degradation (such as in outdoor pools). A better choice would be a hypochlorite disinfectant, which is not going to push the levels of cyanuric acid up and potentially cause chlorine lock. Otherwise, the pool operator will probably always be battling to dilute the excess cyanuric acid out of the pool, which will cause unnecessary work and also has cost implications related to the heating of potentially large volumes of fresh water.

Bromine (BCDMH)

- dry product (pellets, tablets or granules)
- 61% bromine and 27% chlorine
- pH of approx 3-5 (strong acid)

This product, in stick or tablet form, is stable when dry but will emit bromine/chlorine gas in contact with water. When applied, it is important not to mix the product with other chemicals and to keep it well away from all alkaline substances, eg sodium carbonate, calcium hypochlorite, etc.

A circulation feeder device is normally used for the application of this chemical, and it is important that no other chemicals are placed in this device and that, when refilling, splashing should be avoided by lowering the water level. Strong concentrations of this chemical can cause severe burns to the skin and eyes.

BCDMH should be stored in safe containers in secure premises which are cool, dry and away from oxidisable materials such as paper, solvents, wood, oil, etc.

A potential negative aspect on the use of BCDMH is that a small proportion of bathers develop an itch followed by a visible rash within 12 hours of exposure to water treated with this chemical. The problem is unusual in children and more common in bathers of say 50 years or more.

It's not a good choice for outdoor pools as it can't be 'stabilised' against ultraviolet degradation like chlorine can.

Know your chemicals…

It is important that Pool Plant Operators are familiar with all the chemicals involved in pool water treatment.

Note down the *chemical name* (not the brand or trade name) of the disinfectants used at your facility. Make sure you understand their properties and the hazards they present.

Free, Combined and Total Chlorine

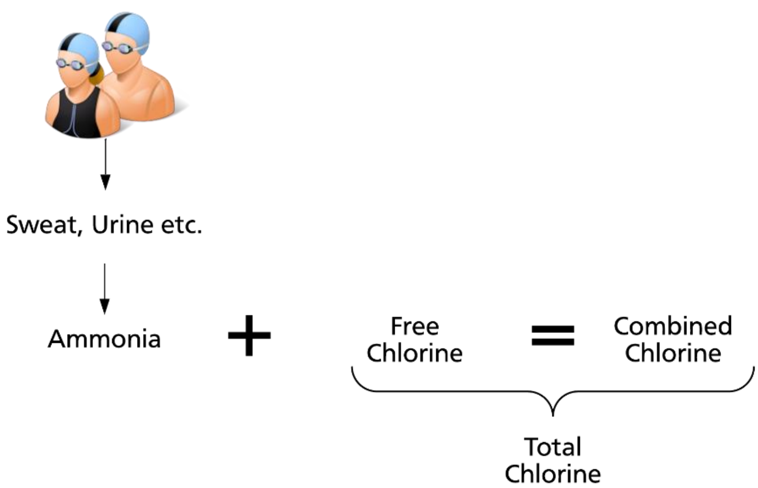
Free Chlorine

Free chlorine is measured with the DPD1 test. It indicates how much of the total chlorine in the pool has not yet reacted with any pollution (i.e., combined) and is therefore free and available to carry out its purpose as a disinfectant.

There should always be enough free chlorine in the pool to minimise the risk of cross-contamination. The recommended range is 0.5 – 2.00mg/l for most types of pool, but spa pools, because of their increased risk of legionella contamination, have a higher recommended range of 3.00 – 5.00mg/l.

Combined Chlorine

When the disinfectant gets into the pool water, the free chlorine contained within in immediately gets to work and starts combining with pollution. Once chlorine combines it hangs around in the pool water and is no longer effective as a disinfectant and is now actually more of a pollutant itself. It needs to be removed from the pool by a combination of dilution and filtration.



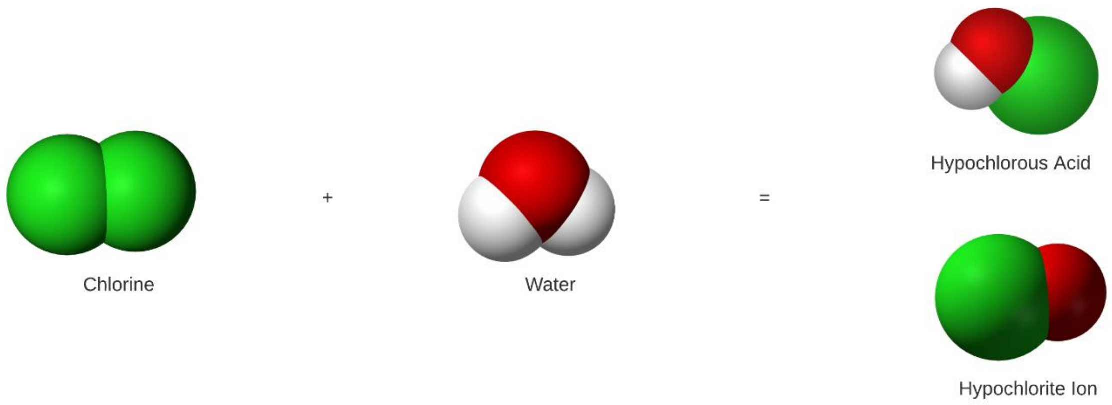
Combined chlorine is measured by calculating the difference between the total chlorine and the free chlorine.

Free Chlorine (DPD1) **+** Combined Chlorine (total minus free) **=** Total Chlorine (DPD3)

E.g.: 1.50mg/l 0.50mg/l 2.00mg/l

The chemical reactions that produce free and combined chlorine

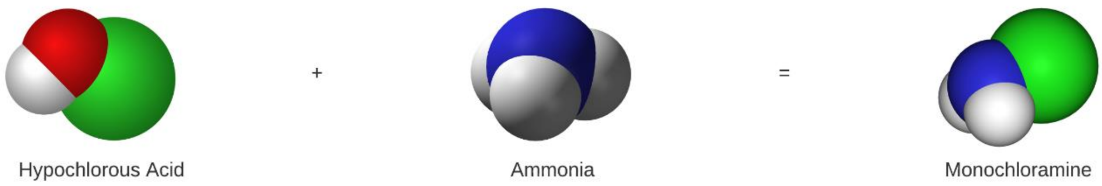
Establishing free chlorine



Chlorine dissolves in water and free chlorine is formed (hypochlorous acid and hypochlorite ion). Example test results:

- Free Chlorine: 2.00 ppm
- Combined Chlorine: 0.00 ppm
- Total Chlorine: 2.00 ppm

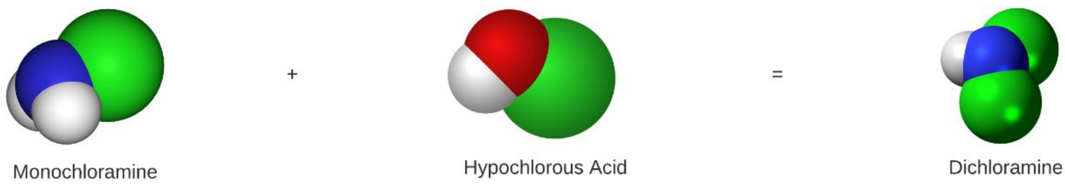
Controlling combined chlorine (well-run pool)



Part of the free chlorine reacts with ammonia and the first part of combined chlorine is formed (monochloramine). Example test results:

- Free Chlorine: 1.50 ppm
- Combined Chlorine: 0.50 ppm
- Total Chlorine: 2.00 ppm

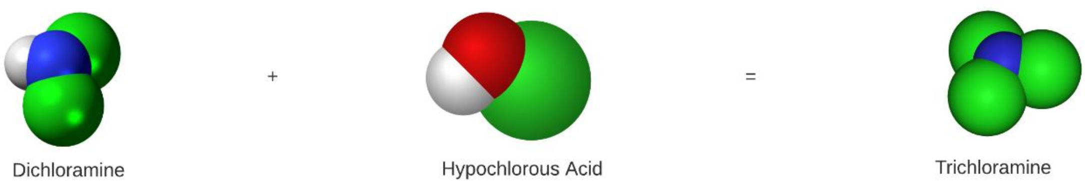
Increasing combined chlorine (things starting to go wrong)



Monochloramine reacts with free chlorine and the second part of combined chlorine is formed (dichloramine). Example test results:

- Free Chlorine: 1.00 ppm
- Combined Chlorine: 1.00 ppm
- Total Chlorine: 2.00 ppm

Excess combined chlorine (badly run pool)



Dichloramine reacts with free chlorine (which might be falling by now) and the third part of combined chlorine is formed (trichloramine). Example test results:

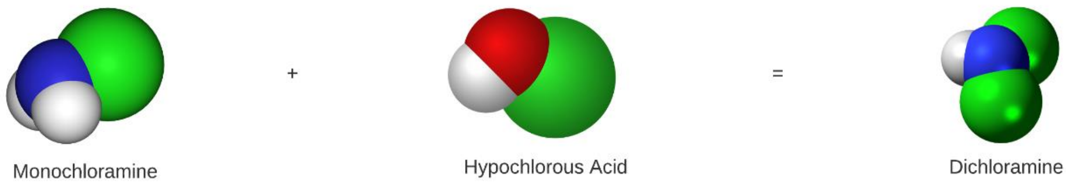
- Free Chlorine: 0.50 ppm
- Combined Chlorine: 1.50 ppm
- Total Chlorine: 2.00 ppm

"We use bromine instead of chlorine. Do the same principles apply?"	The chemical reactions are similar, but the key difference when bromine is used instead of chlorine is that unlike combined chlorine, combined bromine remains effective as a disinfectant. Therefore, the levels of free bromine and combined bromine are not as relevant as the overall level of total bromine and pool operators only need to monitor total bromine with

Breakpoint Chlorination

Now that we've covered free, combined and total chlorine in the previous section, we can go through how to manage the levels of each to give us clean, safe and hygienic pool water.

Let's pick things up from the previous section at the point where things had started to go wrong…



Example test results:

- Free Chlorine: 1.00 ppm
- Combined Chlorine: 1.00 ppm
- Total Chlorine: 2.00 ppm

Here we see that free chlorine is dropping as it continues to convert to combined chlorine. This is a problem as free chlorine is the disinfectant and combined chlorine is an irritant by-product of chlorine reacting with ammonia.

What we should be aiming for is that as more chlorine is dosed into the pool water, as much of it as possible **stays as free chlorine** rather than converting into combined chlorine.

What would be the appropriate course of action?

Option A

Reduce the combined chlorine by diluting the pool with fresh make-up water and encouraging people to take a shower before swimming to minimise the amount of ammonia that contributes to combined chlorine.

Option B

Add more and more chlorine until the desired level of free chlorine is achieved. This can be done by hand-dosing or adjusting the automatic dosing equipment.

Discuss the options with your tutor.

As long as the pool is being well-run, dichloramine will decompose away. When chlorine is added, more of it will remain as free chlorine because there isn't any dichloramine left for it to react with. This phenomenon is known as ***breakpoint chlorination***.

You can say you've achieved breakpoint chlorination when the test results confirm that the level of combined chlorine is less than half the level of free chlorine (if you can get the combined level down to zero, so much the better).

See the table for what a set of chlorine tests indicating breakpoint chlorination might look like.

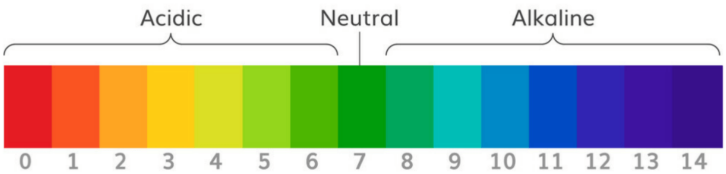
Example test results:

- Free Chlorine: 1.00 ppm
- Combined Chlorine: 0.25 ppm
- Total Chlorine: 1.25 ppm

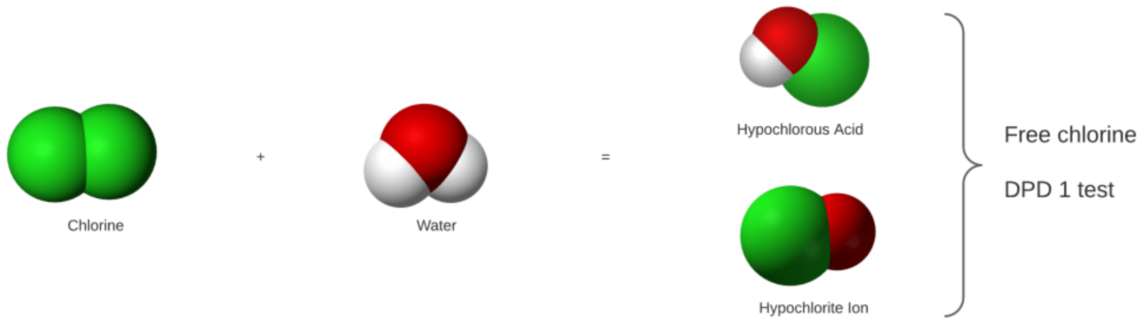
pH

What is pH?

pH stands for 'power of hydrogen'. It's a scale used to specify how acidic or or alkaline a water-based solution is. Acidic solutions have a lower pH, while alkaline solutions have a higher pH.

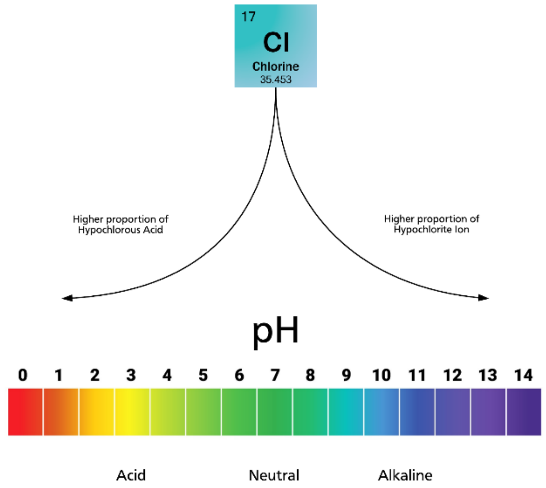


How pH affects chlorine effectiveness

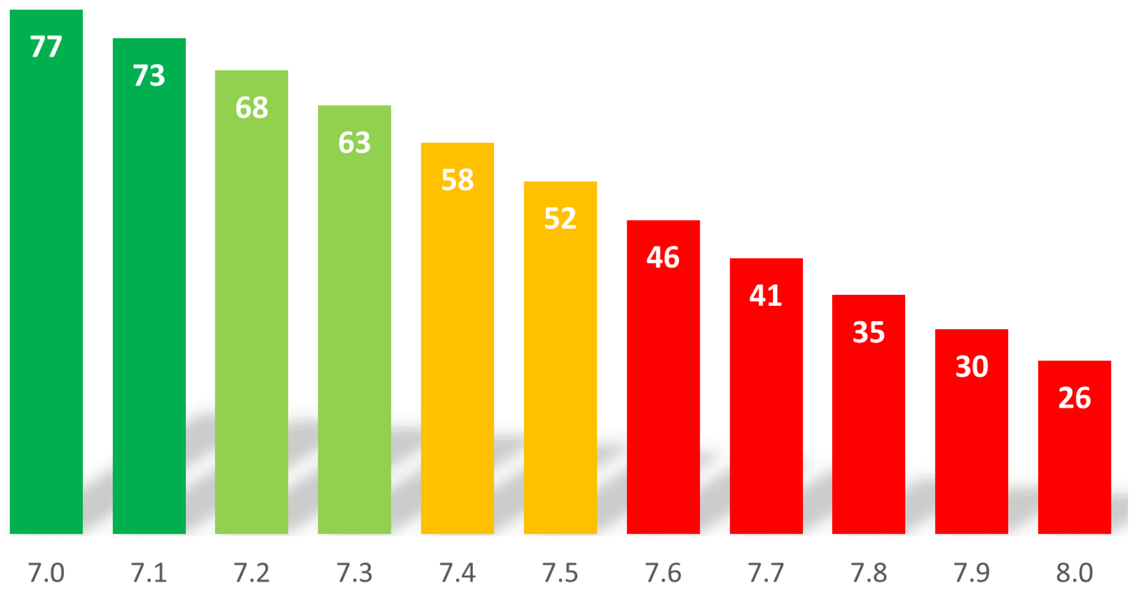


As previously covered, free chlorine comprises hypochlorous acid and hypochlorite ion. Hypochlorous acid is the 'active' disinfecting part of free chlorine. But the higher the pH, the less hypochlorous acid is formed; hence, the less effective the chlorine will be.

The free chlorine reading you get with a DPD1 tablet test includes the hypochlorous acid **and** the hypochlorite ion. But it doesn't tell you the proportion of each, so it doesn't tell you how much of the free chlorine is active.



That means testing for pH is just as important as testing for chlorine. Having the correct level of chlorine means nothing until you know what the pH value is.



Graph shows the decreasing % effectiveness of free chlorine at increasing pH levels. The colours signify degree of tolerance for a commercial public swimming pool: green = ideal, amber/red = action required.

"If hypochlorous acid is the disinfectant within chlorine, why don't we just purchase that instead of the chlorine?"	Despite being relatively easy to make, it is difficult to maintain a stable hypochlorous acid solution because it cannot be isolated from chlorine and water solutions due to rapid equilibration.

Adjusting the pH

As chlorine is continually added to pool water it will be influencing pH. The most common chlorine donors (sodium hypochlorite and calcium hypochlorite) are highly alkaline and will push the pH up.

To correct this, there are several different substances that can be used to adjust the pH level (not at the same time!).

Pool operators will need to select the appropriate substance after consideration of a range of factors, safety being the priority.

To decrease pH

Carbon Dioxide

CO_2 is a non-toxic and non-flammable gas, colourless and odourless but with a characteristic taste and pungency at higher concentrations. The normal concentration of CO_2 in the air that we breathe is approximately 400 ppm (0.04% by volume). If its concentration in the ambient air is increased, the pulmonary gas exchange in the lungs is compromised. In simple terms, as its concentration in the ambient air increases, lower quantities of CO_2 leave the body and so there is less room for oxygen (O_2). Without sufficient O_2 one cannot live. This effect is called intoxication.

CO_2 is easier and safer to handle than other acids – no direct contact. It can be supplied in cylinders or bulk tank. Unlike other acids, it is not possible to mix CO_2 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.

Sodium Bisulphate (Dry Acid)

Sodium bisulphate, sometimes termed dry acid) is supplied in crystal/powder form, generally white. A powder as opposed to liquid is thought to reduce mixing accidents.

It needs to be put into solution before use. As with any acidic liquid it produces chlorine gas when mixed with hypochlorites. Reaction can lead to exposure to a sulphuric acid mist, which over a long period of time is thought to be carcinogenic (may cause cancer). It causes irritation on contact with skin. There is risk of damage to the eyes.

Hydrochloric Acid

Hydrochloric acid is supplied in liquid form of varying strengths. It can be used for pH control when the pool water is treated with sodium or calcium hypochlorite. It is a colourless, odourless, non-fuming liquid when supplied as a 10 or 5% solution. It is a safer acid to handle than sulphuric acid (discussed later).

Stronger solutions (up to 35% concentration) are pungent and fuming and present a greater hazard during handling. Good seals are required when stronger acid strengths are utilised, to prevent the fumes escaping into the atmosphere. Fumes are a threat to the fabric of the building as well as people's health.

It is corrosive substance and can cause skin burns and eye damage on contact; ingestion can burn the mouth, throat and stomach. It is irritating to respiratory system and may cause respiratory failure at acute doses. Chronic exposure may cause asthma

The quantities required for public pools may present a storage problem. As with any acidic liquid it produces chlorine gas when mixed with hypochlorites.

Sulphuric Acid

Sulphuric acid is supplied as a liquid in various strengths. PWTAG has for some time been concerned about the use of concentrated sulphuric acid (48%) for pH correction in swimming and spa pool water.It is a highly dangerous, corrosive acid; the greater the strength the greater the hazard. COSHH (Control of Substances Hazardous to Health) regulations place on employers the responsibility to use the 'least hazardous' chemical that gives satisfactory performance. As with any acidic liquid it produces chlorine gas when mixed with hypochlorites. Great care is required when handling.

Exposure to a sulphuric acid mist over a long period of time is thought to be carcinogenic (may cause cancer). It causes serious skin burns and eye damage on contact with skin, damage to the gastrointestinal tract if ingested, and lung damage if inhaled.

When mixed with water, concentrated sulphuric acid has a vigorous exothermic reaction (i.e., producing heat) and produces significant fumes over and above the background fuming of hydrochloric acid. When dosed via a lance direct from the canister, a residue is left in the bottom of the drum which has to be removed prior to the return of the canister.

Sulphuric acid, when used undiluted direct from the delivered canister or drum, is of higher concentration compared with other acids and therefore very effective. Canisters can be fitted directly with suction lances, so only the canister needs to be handled, reducing exposure to the operator.

If there is no bulk storage facility, sulphuric acid should not be dosed via a day tank so that operators do not have to transfer the liquid from the drum that it is delivered in. All of the dosing equipment should be fitted with suction lances to fit the drum of which the acid is delivered. This means that, as with hydrochloric acid, exposure of this acid to the operator is minimised.

If it is used, it should not be as concentrated acid (48%) but diluted to 25% or lower by the supplier. Personal protection equipment should be worn when handling it (as for all of these chemicals).

Dosing needs to be monitored initially very carefully and dosed as required to adjust the pH slowly. Dosing should be undertaken only using an automatic dosing device (control of dosage and pH with pH electrode).

If pools are using a calcium hypochlorite circulation feeder whose nozzles need cleaning with acids, hydrochloric acid is the safer choice. In any case, the acid used must be stored appropriately, the manufacturers' instructions followed, and the acid flushed out to waste before any acid is fed again.

Dealing with Spillages

Small spillages can be neutralised by containing the spill and using a spill kit to neutralise the acid. Larger spillages should be dealt with by calling the Fire & Rescue Service.

Bulk Delivery Warning

A key risk is the potential for mixing if the delivery person connects to the wrong bulk tank. Although different size nozzle adapters are installed at design, some delivery drivers carry delivery nozzle adaptors so that they can deliver into any tank, whatever the site tank connector size.

To increase pH

Sodium Carbonate (Soda Ash)

Sodium Carbonate (sometimes known as Soda Ash) is a dry, white powder that is used to ***increase*** the pH level.

It would be used in situations where the pool is using an acidic disinfectant (eg. stabilised chlorine).

Know your chemicals…

It is important that Pool Plant Operators are familiar with all the chemicals involved in pool water treatment.

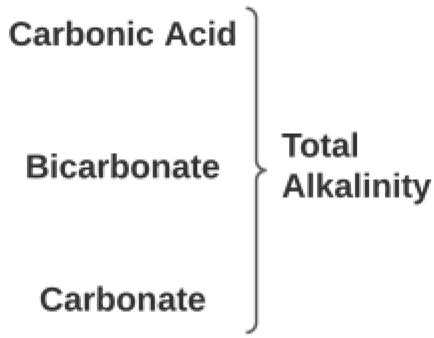
Note down the *chemical name* (not the brand or trade name) of the pH correctants used at your facility. Make sure you understand their properties and the hazards they present.

Note: if you accidentally mix acid with chlorine, you could end up releasing highly toxic chlorine gas!

pH Buffering

The pH must remain stable and not fluctuate in response to all the various chemical reactions in the water. Therefore, the pH of pool water needs to be ***buffered***.

In pool water treatment buffering refers to a particular chemical reaction between three chemicals collectively known as ***total alkalinity***.



Total Alkalinity should be tested weekly to ensure the pH is sufficiently buffered. This test is covered later in the pool water testing chapter. The recommended level to maintain is 80 – 200 ppm. Without this chemical reaction, the pH levels would be impossible to control.

pH Bounce

Too little Total Alkalinity will lead to fluctuating pH as there won't be enough of the buffering chemical reaction. This is 'pH bounce'. Sodium Bicarbonate is the chemical used to increase Total Alkalinity.

pH Lock

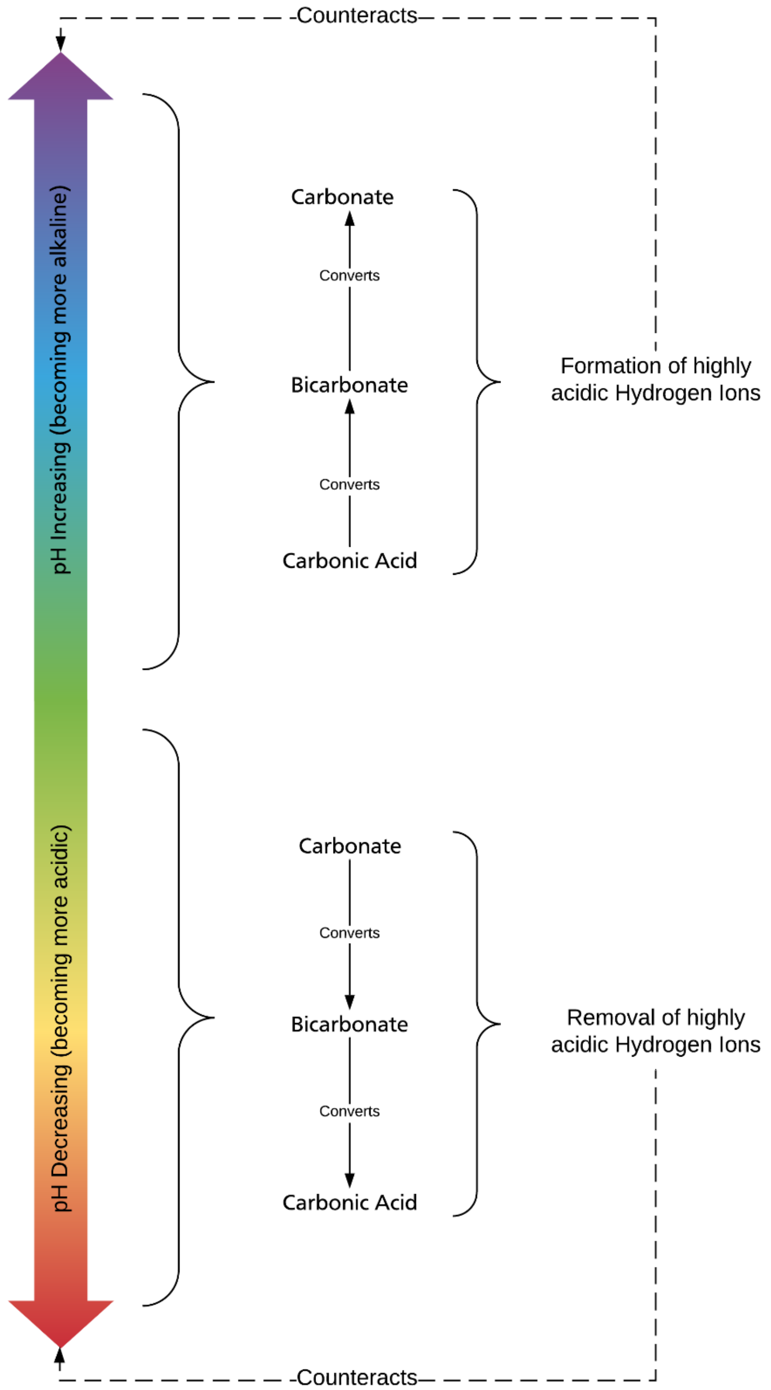
Too much Total Alkalinity will lead to stuck pH levels. It will not respond despite efforts by the pool operator to increase/decrease pH. This is called 'pH lock'. Dilution with fresh water into the pool is the way to reduce Total Alkalinity.

When the pH level is increasing, carbonic acid converts to bicarbonate and as it keeps increasing, bicarbonate converts to carbonate.

As a result of this reaction, when the pH level increases, acidic hydrogen ions are formed which counteracts the increasing pH.

When the pH level is decreasing carbonate converts to bicarbonate and then carbonic acid,

As a result of this reaction, when the pH level decreases acidic hydrogen ions are removed, which counteracts the decreasing pH.



Dosing Sodium Bicarbonate

To get the sodium bicarbonate in the pool, make up a solution by dissolving the sodium bicarbonate in cold water (not pool water) and then distribute it as widely as possible over the surface of the pool. Dosage is 17 grams per cubic meter of pool volume to increase total alkalinity by 10.00 ppm

Secondary Disinfection

Chemical disinfection with chlorine or bromine is referred to as primary disinfection. Supplemental disinfection with either ultra violet or ozone is referred to as secondary disinfection.

PWTAG says that due to the risk of infection from the disinfectant-resistant protozoan, Cryptosporidium, it is recommended that swimming pools include secondary disinfection systems to minimise the risk to bathers associated with such outbreaks. This is particularly important with pools used by young children. There are other benefits in water quality, including being able to have lower disinfectant residuals in the pool water.

Residual and Non-Residual Disinfection

Residual disinfectants refer to disinfectants that are present in the pool water all the way around the system. If you were to take a sample of pool water from anywhere in the pool and around the circulation system, there should be adequate levels of disinfectant present. This is different from non-residual disinfectants. With non-residual disinfectants, the disinfecting component is only present at the point of contact. So, with an ultra violet system, the ultra violet light, which is the disinfectant component, is only present inside the ultra violet chamber. Pool water gets circulated through this chamber and it is at this point of contact that the disinfection process takes place, nowhere else. It’s the same sort of thing with an ozone system in that the ozone gas that the system generates is only present in the ozone generator and the vessel that is used to mix the ozone with the pool water. The ozone is then filtered out of the pool water before it gets returned to the pool.

Ultra Violet

Ultra violet disinfection is a process whereby the swimming pool water flows through a UV chamber and is exposed to UV light. UV should be applied to the full flow, medium pressure at 60mj/cm2 and monitored to ensure an effective dose rate. The UV light is harmful to bacteria and other micro-organisms because it mutates the DNA of the organism, which means that it can no longer reproduce. The UV chamber is installed in the plant room and once the swimming pool water has passed through the chamber, it will have been purified to the extent that any chlorine in the water will have also been removed. UV disinfection is a physical, not a chemical process and nothing is added to the swimming pool water when it passes through the UV chamber. This means that UV treatment is a non-residual form of disinfection and a disinfectant such as chlorine will need to be added before the water recirculates back to the swimming pool.

Some advantages of UV disinfection systems are that there are no chemicals to handle or store and once installed, the system does not take up too much space or require high levels of expertise to operate (unlike ozone disinfection systems). Also, it does not produce chemical by-products like chlorine does.

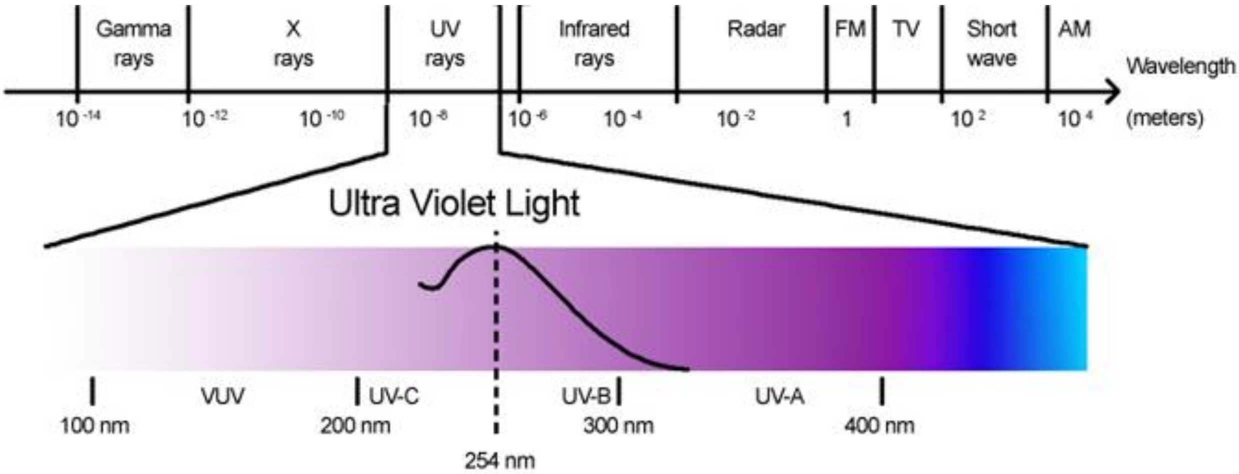
Ultraviolet radiation (UVR) has shorter wavelengths and more energetic photons (particles of radiation) than visible light.

UVR is sub-divided into three bands, depending on wavelength:

- UVC is very short-wavelength UVR and is theoretically the most harmful to humans, however UVC radiation from the sun is filtered out in the atmosphere. In practice human exposure is only available from artificial sources, such as germicidal lamps.
- UVB is mid-wavelength and is the most biologically damaging UVR, which causes sunburn and other biological effects.
- UVA has the longest wavelength and is normally found in most lamp sources. Although UVA can penetrate deeply into tissue, it is not as biologically damaging as UVB.

The curved black line in the diagram below shows the germicidal effectiveness of ultra violet light at different wavelengths.

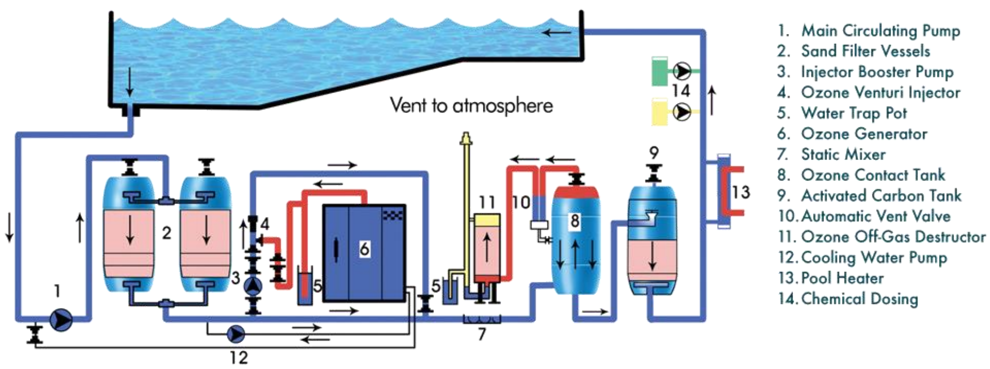
UV lamps are either low pressure or medium pressure, referring to the pressure of mercury vapour inside them. Low pressure lamps produce short wavelength UV (254 nm). Medium pressure lamps produce a wider range of wavelength, from short wavelength through to visible light and are better at removing chloramines. It should be noted that UV lamps have a useful life of between 8,000 – 10,000 hours before they need to be replaced (one year is 8,760 hours).



Ozone

Ozone is a disinfection method that uses ozone to oxidise contamination in the pool water. Ozone should be applied to the full flow of water through the treatment plant, with separate contact and deozonising systems. Contact time should be at least two minutes, and the ozone concentration should be1mg/l of water circulated. Ozone should not be used with bromine-based disinfectants due to the production of harmful levels of bromate.

Ozone is a more powerful oxidiser than chlorine and will actually oxidise (and therefore, remove) chlorine from the pool water when it passes through the ozone dosing system. It is a non-residual disinfectant, which means that no ozone remains in the pool water once it has passed through the ozone dosing system in the plant room. This is different to chlorine because under normal circumstances, there will always be some chlorine in all areas of the swimming pool water circulation system, including the swimming pool itself. Because of this, where an ozone disinfection system is installed, there must also be an additional disinfection dosing system (such as chlorine). Without this, the swimming pool water would be re-polluted as soon as it circulated back into the swimming pool and this pollution would only be removed when the water goes through the pool plant system again. This is not sufficient to



control the cross-contamination risk in swimming pools. Bacteria needs to be killed within seconds in order to minimise the risk. However, the use of ozone will allow pool operators to use substantially lower levels of chlorine (as low as 0.5 mg/l). Another advantage is that ozone will kill cryptosporidium, whereas chlorine does not.

Ozone is not delivered to site, it is generated on-site. This means that there are no handling and storage issues. Ozone is a very toxic substance though and the on-site generation method means that extra training is required for pool plant operators. It is generated by passing an electrical discharge through dried air in an ozone generator, then it goes to a mixing vessel where it is mixed with the pool water, once the pool water and ozone have been mixed together it goes into a contact vessel because ozone needs about 2 minutes of contact time with the pool water in order to be effective, then it goes through a filter to remove all of the ozone from the pool water. The purified pool water then carries on its journey through the pool plant system and the air and any undissolved ozone goes through an ozone removal system before being vented externally. As you can see, ozone disinfection requires quite a lot of equipment, which can be an issue, as can the high levels of expertise required to operate and maintain the system safety.

Knowledge Test (check answers with tutor)

Enter the missing words from the following list into the blank spaces:

- free
- combined
- total

free chlorine + ______ chlorine = ______ chlorine

combined chlorine = ______ chlorine – ______ chlorine

What is the ideal free chlorine reading for a standard swimming pool where the pH is 7.0 – 7.2?

- ○ 0.75 – 1.00 mg/l
- ○ 2.50 – 5.00 mg/l
- ○ 3.00 – 5.00 mg/l

Which chemical has the following properties:

- dry product (pellets, tablets or granules)
- 65 – 70% chlorine
- pH of approx 10 – 11 (strong alkali)
- recommended for soft water areas
- long storage time

What is the maximum allowable level of combined chlorine?

- ○ < 50% of free chlorine and/or < 1.00 mg/l
- ○ An equal level to the free chlorine
- ○ Twice the level of the free chlorine

If the free chlorine is 1.50 mg/l and the total chlorine is 1.75 mg/l what is the combined chlorine?

Carbonic acid, bicarbonate and carbonate (collectively known as total alkalinity) has what effect on pH?

○ Decreases pH

○ Increases pH

○ Buffers the pH, making it more stable and less prone to fluctuations.

What happens to the chlorine as the pH increases?

- Chlorine effectiveness decreases
- Chlorine effectiveness increases
- No effect

What chemical has the following properties:

- wet product (liquid)
- 10 – 15% chlorine
- pH of approx 13 (strong alkali)
- recommended for hard water areas
- short storage time

Fill in the blank below.

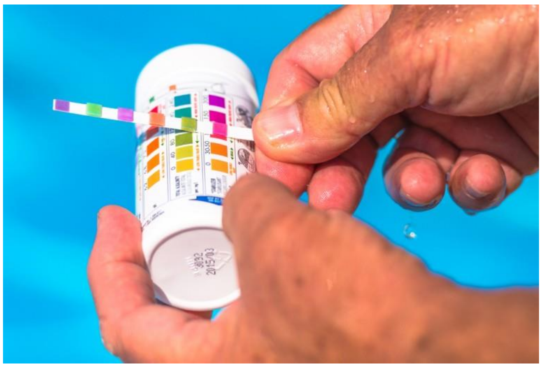
_______ chlorination describes a situation where it is the free chlorine residual, rather than the combined chlorine residual that increases with the addition of more chlorine into the swimming pool water.

07. Pool Water Testing

On completion of this lesson, you'll know how to monitor the chemical properties of swimming pool water on a day-to-day basis and what actions to take to correct any of these chemical levels if they should fall outside of recommended ranges.

General Guidance on Water Testing

Commercial pools should use either a **photometer** or a **comparator** for routine water testing. Water testers or test strips are not suitable for commercial pools.



Test strips – NOT suitable for commercial pools

A water tester – NOT suitable for commercial pools

A comparator – suitable for commercial pools

A photometer – suitable for commercial pools

Both are covered in this course, but we recommend photometers over comparators because (depending on the make and model) they are usually more user friendly than comparators.

- the equipment used should be clean and dry
- photometers should be re-calibrated on an annual basis
- reagent tablets should not be touched as this would affect the reading
- put test tubes on a stable, flat surface when crushing the reagent tablets
- samples should be collected in a plastic beaker (not glass)
- if results are not as expected, always do an immediate re-test
- pool testing and effective lifeguarding cannot be carried out at the same time

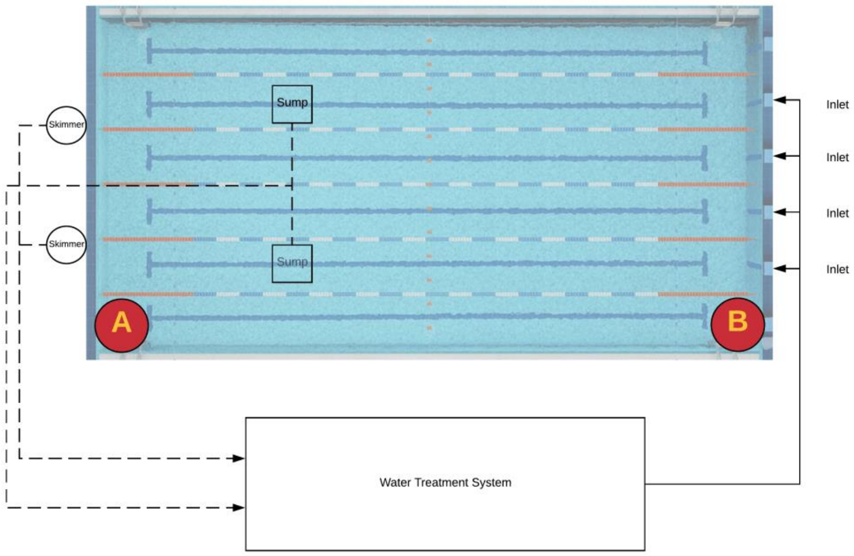
Where to take samples from

The point of water testing is to ensure that there is enough disinfectant in the water, (at the correct pH level) to kill the germs. Therefore, when taking samples, it's important that you collect them from a spot within the pool that is most likely to have the lowest level of disinfection. That way, you can be reasonably confident that everywhere else will have enough disinfectant too.

In terms of the correct depth, it is recommended that the sample should be taken from within the top 150mm of pool depth. This is where most of the pollution lies within the pool and is therefore representative of 'worst-case scenario'.

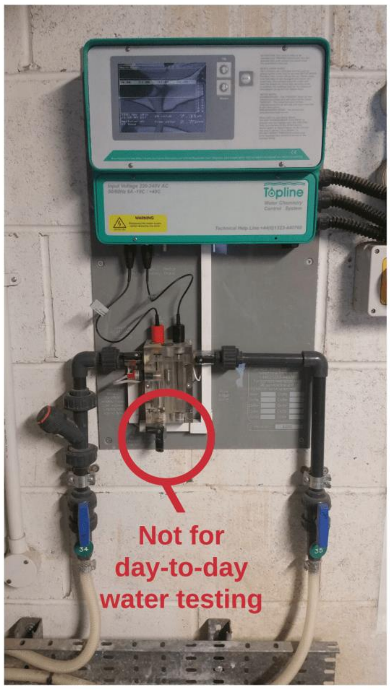
Where would be the best location to take a sample for water testing?

- Location A
- Location B



Do not take the samples for routine testing from the sample point on the monitoring system in the plant room. This sample point is not intended for this purpose (it's for calibrating the sensors in the monitoring equipment against a sample of water taken from the same location on the system as the sensors).

All tests carried out on the pool water should be recorded accurately and stored in a system that allows for easy retrieval. Electronic recording and storage of data is acceptable, but may not be the most practical option, given the environmental conditions.



"How often should tests be done and should records be kept?"	The pool water should be tested throughout the day to ensure that the water is safe to enter. The first test should be carried out before the first swimmers are allowed in, giving the operator plenty of time to rectify any issues that may become apparent following the first round of tests. Thereafter, while the pool is in use, the frequency of testing for disinfectant levels and pH value should be as follows: • Spa pools: every 2 hours • Swimming pools without automatic chemical dosing: every 2 hours • Swimming pools with automatic chemical dosing: every 3 – 4 hours * * This frequency should be increased/decreased according to site-specific circumstances. For example, in pools that experience very low usage and have a reliable automatic chemical dosing system, it may be possible to extend the period between tests. The main thing is to ensure that you test frequently enough so that you become aware that the levels are starting to move outside of acceptable parameters before those parameters are actually breached. If you find that the levels are already outside of the acceptable parameters when you come to test them, the testing is not being carried out frequently enough, or the results of tests are not being responded to in the correct way.

Comparators and Photometers

Photometers

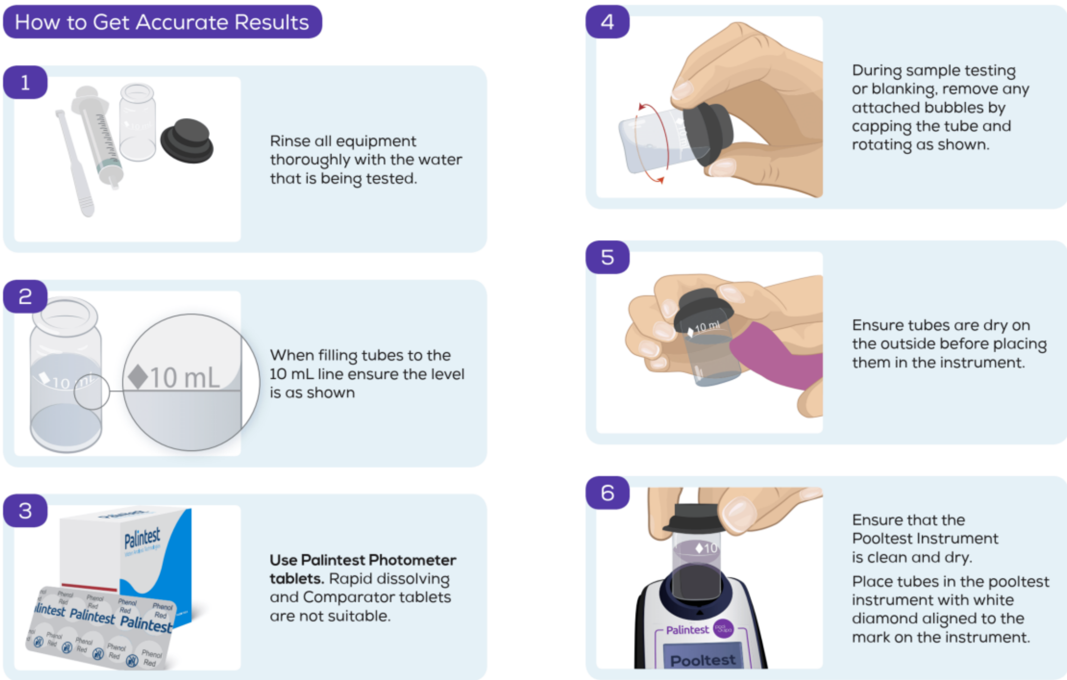
These are devices that work electronically. A test tube containing a sample of pool water is placed in the device. Tests are based on measuring the intensity of colours produced by reagents.

All external light must be prevented from leaking into the sample. To achieve this, some photometers have a separate light cap. Other photometers achieve it by the test tube caps being designed to fit snugly to stop light from entering the sample.

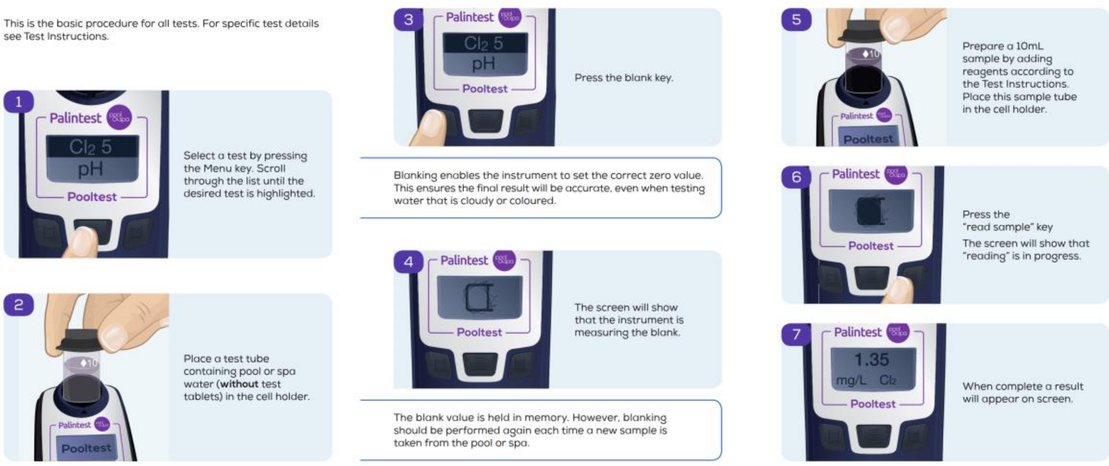
Blanking

The blank is a sample of the water to be tested that sets the zero value on the instrument. This ensures that any colour or cloudiness in the sample does not affect the final result. Blanking is required whenever a different pool or spa is being tested or if significant time has elapsed since the pool or spa was last tested. In the test instructions, blanking is not explicitly described. However, the photometer must be blanked using the water that is being tested.

How to get accurate results when using a photometer



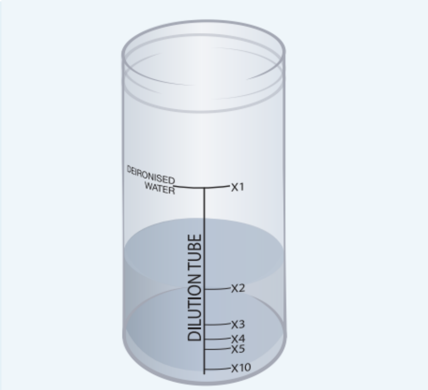
Selecting and Performing Tests on a Photometer



Sample dilution

If a result is above the range of the test a '>' symbol will appear in front of the result. In this case it will be necessary to dilute the sample with deionised water and repeat the test.

Important: pH and Alkalinity tests are not suitable for dilution.



A dilution tube is available from Palintest to simplify this.

Example for a x2 dilution:
Fill with sample to x2 line and top up to 100 mL with deionised water. Mix and use this as the new blank and sample for the test. Multiply result by x2.

Comparators

Comparators work by inserting a water sample next to another with a reagent dissolved in it and then inserting a colour wheel. The tester then holds the comparator up to the light and compares the colour of the two samples. Next, the colour wheel is rotated until the closest match is found. A reading is then taken from the small circular display aperture.

Instructions for using a comparator

1. Select the correct colour disc for the parameter under test. Insert the disc into the Comparator, ensuring the numbers face the user.
2. Place the square test tube containing the treated sample in the right-hand side of the tube holder. A square test tube containing the sample only should be placed in the left-hand side of the tube holder to compensate for any inherent colour in the sample.
3. Hold the Comparator against a source of white light, such as north daylight or use a Palintest Light Unit and rotate the disc until the colours are seen to match.
4. Take the disc reading in the aperture on the front of the Comparator.

Chlorine and pH Test Instructions (photometer and comparator)

Chlorine test instructions

Free and Total Chlorine - Cl_2 5 and Cl_2 10	
Colour Change:	Colourless to Pink
Two Ranges:	0 – 5 mg/L use DPD 1 and DPD 3 Tablet 0 – 10 mg/L use DPD XF and DPD XT Tablet

1

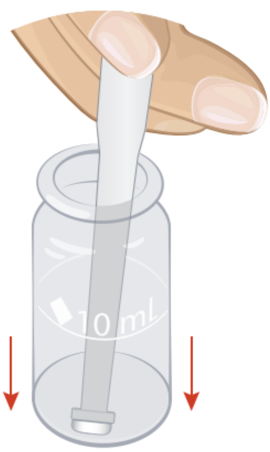
Rinse tube with sample leaving **a few drops.**

2

Add **one DPD 1** or **one DPD XF** Tablet.

3

Crush tablet to form a paste.



4

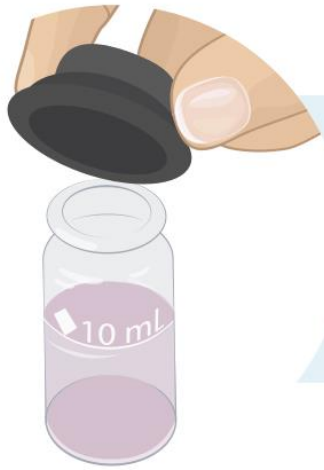
Fill with further sample to the **10 mL** line.

5

Stir.

6

Cap the tube.



7

Take the **Photometer Reading.**

Result = Free Chlorine

8

Keep tube and contents to measure Total Chlorine.

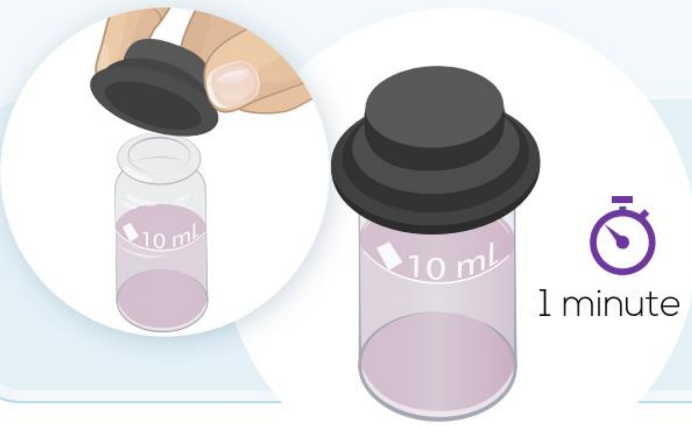
If no shock treatment has been used, continue to step 12.

9

Add **one Oxystop Tablet**.

10

Crush and Stir.



11

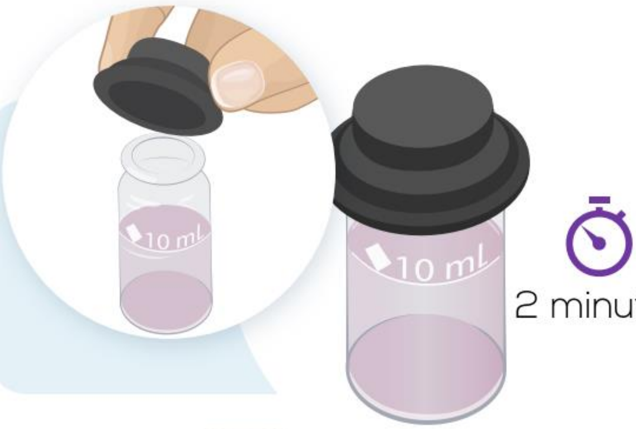
Replace cap and wait.

12

Add **one DPD 3 or DPD XT Tablet**.

13

Crush and stir.



2 minutes

14

Replace cap
and wait.

15

Take the **Photometer Reading.**

Result = Total Chlorine

NB: Combined Chlorine =
Total Chlorine – Free Chlorine

If using a comparator

Prepare the blank and test sample in the same way as for a photometer (using comparator test tubes instead of photometer test tubes), then follow these steps:

1. Put 'blank' test tube in the left slot and the test tube with the test tablet into the right slot.

2. Insert the test wheel into the comparator so that you can see the numbers displayed in the little circular aperture.

3. Hold the comparator up to a good source of light and observe the colour match.

4. Rotate the chlorine wheel until the best match is achieved.

5. Record the reading on the pool test sheet.

pH test instructions

pH (Phenol Red)	
Colour Change:	Yellow to Red
Range:	6.5 – 8.4

1

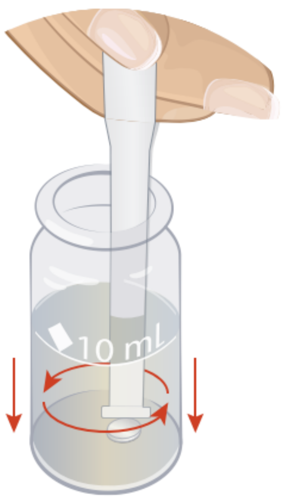
Fill tube with sample
precisely to 10 mL.

2

Add **one Phenol Red tablet**.

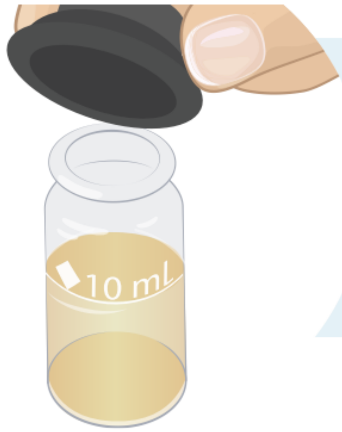
3

Crush and stir.



4

Replace cap.



5

Take the **Photometer reading**.

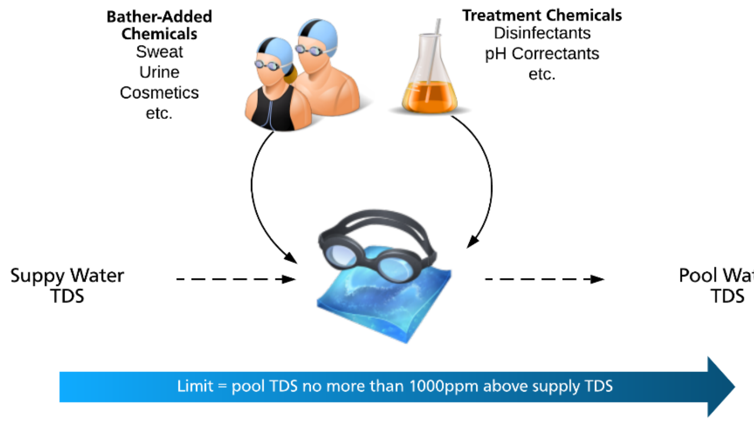
If using a comparator

Prepare the blank and test sample in the same way as for a photometer (using comparator test tubes instead of photometer test tubes), then follow these steps:

1. Put 'blank' test tube in the left slot and the test tube with the test tablet into the right slot.
2. Insert the test wheel into the comparator so that you can see the numbers displayed in the little circular aperture.
3. Hold the comparator up to a good source of light and observe the colour match.
4. Rotate the chlorine wheel until the best match is achieved.
5. Record the reading on the pool test sheet.

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) is a measure of the dissolved combined content of substances present in a liquid.



The levels of chemical pollution in the pool water can be measured using a 'Total Dissolved Solids' meter (TDS meter). This measures the electrical conductivity of the pool water. Water is not a conductor of electricity. Therefore, the more conductive a sample of pool water is, the more it contains by way of elements other than water. This is because the chemicals dissolved in the pool water conduct electricity, not the water itself.

Tip: When purchasing a TDS meter, make sure you get one that measures in parts per million (PPM), rather than parts per trillion (PPT).

The levels of chemical pollution need to be kept under control, otherwise the pool will look cloudy and unclean and will also cause a bad 'chlorine smell' and cause bathers discomfort through eye irritation and rashes etc. The TDS level of the swimming pool should be kept well below 1000mg/m^3 above the TDS level of the mains water supply. The best way of controlling chemical pollution is via prevention. Minimising the amount of chemical pollution being introduced into the pool via bathers is the first step. This will then lead to the pool operator not having to add as much disinfectant to the pool, which leads to not having to add as much pH correctant onto the pool either. Bather pre-showering is the most effective way of minimising the amount of chemical pollution that bathers introduce into the swimming pool water.

Chemical pollution can also be controlled re-actively (after the pollution has entered the water) by a process of dilution, which is where an adequate supply of clean, fresh water (usually from the mains supply) is introduced into the pool on a regular basis. The recommended rate of dilution is 30 litres of fresh water to be added per bather, per day.

Total Alkalinity test instructions

Total Alkalinity - T-Alk	
Colour Change:	Yellow to Green to Blue
Range:	0 – 500 mg/L $CaCO_3$

1

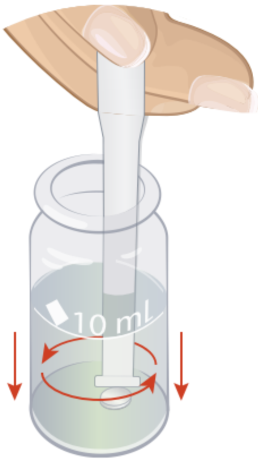
Fill tube with sample
to the **10 mL** line.

2

Add **one Alkaphot™ tablet**.

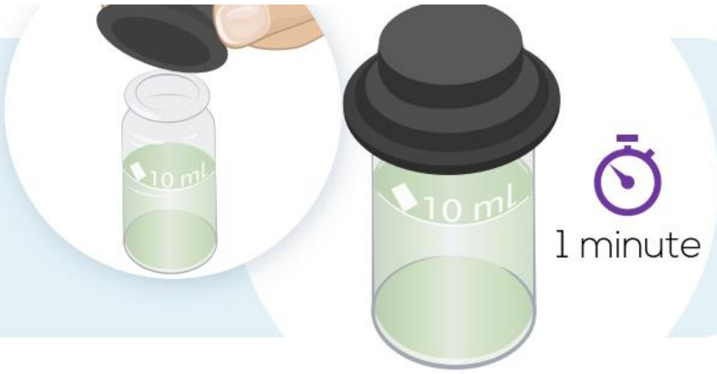
3

Crush thoroughly and mix.
Ensure all particles have
completely dissolved.



4

Replace cap
and wait.



5

Mix again
(if the colour is not uniform).

6

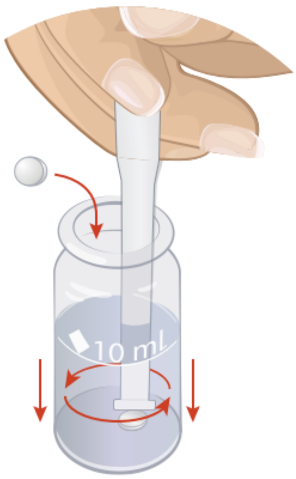
Take the **Photometer reading**.

Calcium Hardness test instructions

Calcium Hardness - Calc & Calc NaCl	
Colour Change:	Violet to Orange
Range:	0 – 500 mg/L $CaCO_3$

1

Fill tube with sample
to the **10 mL** line.

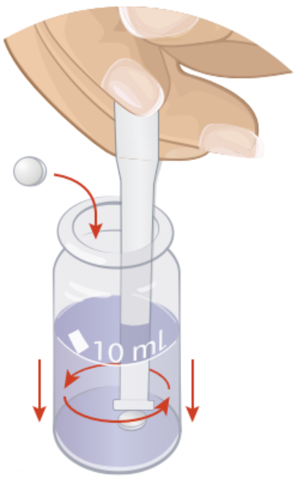


2

Add **one Calcicol No 1 tablet**,
crush and mix.

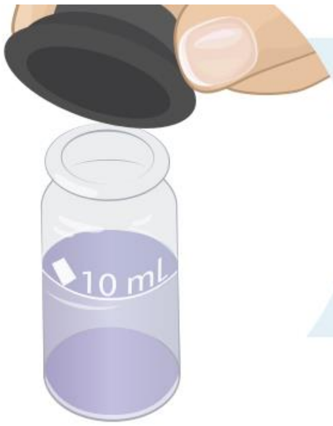
3

Add **one Calcicol No 2 tablet**,
crush and mix.



4

Replace cap.



5

Wait.

6

Take the **Photometer reading**.

Shaker bottle method

If you do not have a photometer that can test for calcium hardness or total alkalinity, the shaker bottle method can be used.

To test the calcium hardness, get a sample of 50ml of pool water in the bottle, add a calcium hardness tablet, put the cap on the bottle and give it a shake. The colour of the water will initially turn pink. Keep adding tablets whilst keeping count until the water colour changes to violet. Multiply the number of tablets it took to achieve the colour change by 40 and then subtract 20. See below for a worked example:

5 tablets X 40 – 20 = 180 mg/l Calcium Hardness

For total alkalinity, use a 100ml sample and follow the same process as for calcium hardness, only this time the colour initially is yellow and changes to bright red. Multiply the number of tablets used by 20 and subtract 10. See below for a worked example:

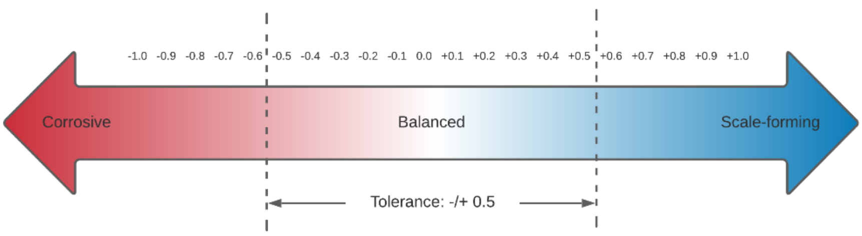
5 tablets X 20 – 10 = 90 mg/l Total Alkalinity

Water Balance Test Instructions

How and why poor water balance can be so costly

Water that is not balanced will cause costly maintenance issues down the line.

The formula for determining whether the water is balanced is often called the Langelier Index, the Langelier Saturation Index, or simply the Balanced Water Calculation.



Pool water that is significantly corrosive will be 'hungry' for calcium and will eat away at materials that contain it, such as tile grout. It will also cause corrosion attack in the pool hall due to the continual evaporation and re-condensation of pool water onto fixtures and fitting and structural elements of the building.

Scale-forming water can lead to a build-up of scale which can affect flow-rates, pressures, heat exchangers as well as provide potential colonisation opportunities for biological agents such as legionella bacteria.

When water is in balance, it is said to be neither corrosive nor scale-forming. For most well-run pools, the water will be in balance if the pH value is kept within the recommended range, but other factors should be considered which can affect the condition of the water. These are the total alkalinity, the calcium hardness, the total dissolved solids content and lastly, the temperature of the water. The concentration of chlorine or bromine does not factor into the Balanced Water Calculation.

How to calculate water balance

Step 1. Carry out tests and note results for:

- pH
- Calcium hardness
- Total alkalinity

- Pool water temperature
- Total dissolved solids

Step 2. Convert the results from the above tests to factors as indicated in the tables below (figures in bold provide a worked example).

Step 3. Add the factors for temperature, calcium, alkalinity to the pH (there is no factor for pH)

Step 4. Minus the factor for TDS from the figure obtained in step 3

Calcium Hardness

Result	Factor
5	0.3
25	1.0
50	1.3
75	1.5
100	1.6
150	**1.8**
200	1.9
300	2.1
400	2.2
800	2.5
1000	2.6

Total Alkalinity

Result	Factor
5	0.7
25	1.4
50	1.7
75	1.9
100	**2.0**
150	2.2
200	2.3
300	2.5
400	2.6
800	2.9
1000	3.0

Temperature

Result	Factor
0	0.0
3	0.1
8	0.2
12	0.3
16	0.4
19	0.5
24	0.6
29	**0.7**
34	0.8
40	0.9
53	1.0

Total Dissolved Solids (TDS)

Result	Factor
1000	**12.1**
2000	12.2
3000	12.3

1.8 + 2.0 + 0.7 + 7.4 - 12.1 = -0.2

The ideal result is somewhere between +/- 0.5. The pH level is the value that has the most impact on water balance test results. A high pH would contribute to scale-forming water, a low pH would contribute to corrosive water. However, it is not advisable to start adjusting pH levels just to try and get good water balance results, as pH is a critical factor in the efficiency of your disinfection and coagulation, both of which are more important than water balance results. Better ways to either increase or decrease the water balance result are listed below:

To increase:

- Increase the levels of calcium hardness by adding calcium chloride
- Increase the levels of total alkalinity, by adding sodium bicarbonate
- Reduce the TDS levels (if they are particularly high) by diluting with fresh water.

To decrease:

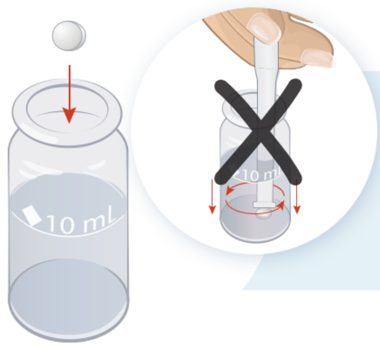
- Look at your pH result. If it's high, you need to decrease it anyway as your chlorine is not going to be as effective at higher pH levels
- Reduce the levels of calcium hardness by diluting with fresh water
- Reduce the levels of total alkalinity by diluting with fresh water.

Cyanuric Acid Test Instructions

Cyanuric Acid - CYA	
Colour Change:	Clear to Cloudy
Range:	0 – 200 mg/L CYA

1

Fill tube with sample to the **10 mL** line.



2

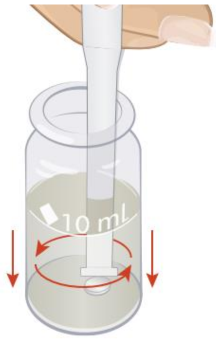
Add **one Cyanuric Acid tablet. DO NOT CRUSH.**

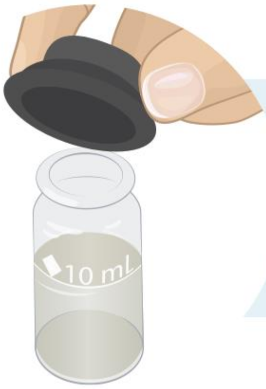
3

Wait (to let tablet disintegrate).

4

Crush any remaining tablet and mix.





5

Replace cap.

6

Take the **Photometer reading**.

Knowledge Test (check answers with tutor)

Number the pH test steps into the correct sequence.

Crush and stir.

Take the Photometer reading.

Fill tube with sample precisely to 10 mL.

Replace cap.

Add one Phenol Red tablet.

Diluting the pool with fresh supply water is one of the most effective ways of controlling pollution and reducing the level of Total Dissolved Solids (TDS).

What is the recommended rate of dilution per bather, per day?

- ○ 60 litres
- ○ 30 litres
- ○ 10 litres

Fill in the blanks below.

To ensure effective coagulation and a stable pH, total alkalinity in pool water should be maintained at a level between [ ] mg/l and [ ] mg/l.

Number the free and total chlorine test steps into the correct sequence.

Add one DPD 1 Tablet.

Crush and stir.

Add one DPD 3 Tablet.

Fill with further sample to the 10 mL line.

Take the Photometer Reading. Result = Total Chlorine

Stir.

Rinse tube with sample leaving a few drops.

Crush tablet to form a paste.

Keep tube and contents to measure Total Chlorine.

Take the Photometer Reading. Result = Free Chlorine

Cap the tube.

Replace cap and wait. 2 minutes

Use the information provided below to determine the water balance.

pH = 7.1
Calcium Hardness = 200mg/l
Total Alkalinity = 150mg/l
Temperature = 29
Total Dissolved Solids = 1000ppm

Why should the DPD1 tablet be added to only a few drops of sample water (rather than the full 10ml) when performing a free chlorine test?

- ○ It makes the DPD1 tablet easier to dissolve.
- ○ The DPD1 tablet can cause too many air bubbles if added to 10ml.
- ○ To enable observation of a bleaching effect in the case of a very high chlorine concentration.

Fill in the blanks below.

Pool water should be maintained for bather comfort, and grout should withstand that water. Ideally, calcium hardness should be maintained between ☐ mg/l and ☐ mg/l.

The samples for routine pool water tests should be taken from the sample point incorporated into the automatic monitoring system.

- ○ False
- ○ True

08. Chemical Dosing Operations

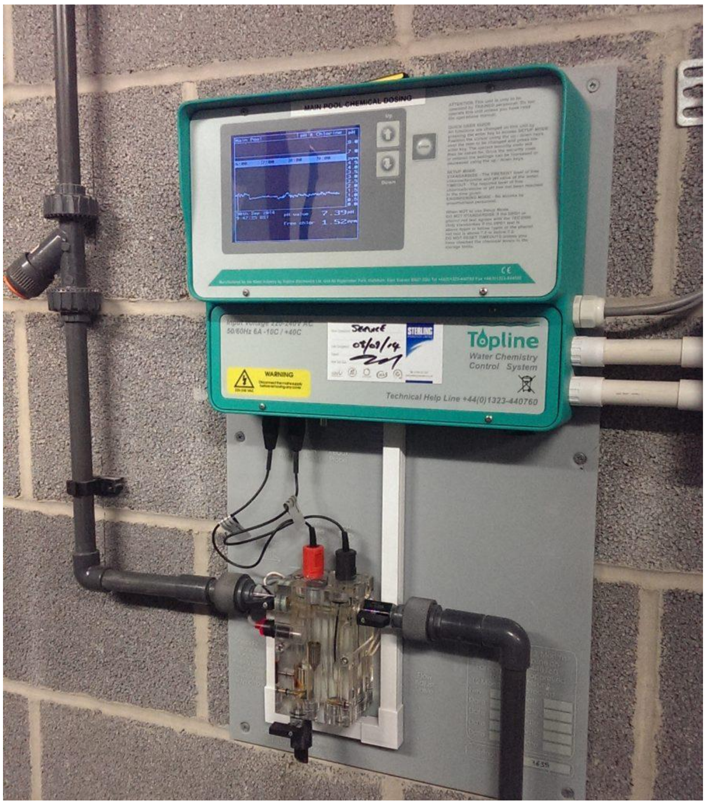
On completion of this lesson, you'll know all the various chemicals involved with pool water treatment, including their proper chemical names and how to safely operate automatic chemical dosing systems as well as knowing how to safely dose chemicals by hand when the need arises.

Automatic Monitoring Systems

What is an automatic monitoring system

A typical automatic monitoring system comprises a control unit connected to probes supplied with a sample of pool water via a sample line taken from the circulation pipework in the plant room.

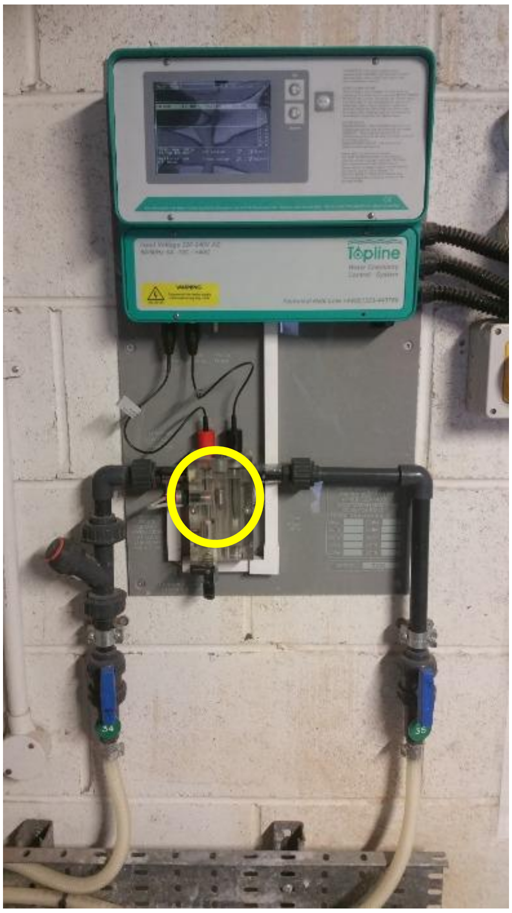
These probes are constantly monitoring the levels of free chlorine and pH. They are electrically linked to pumps that operate according to the probes' readings and the parameters pre-programmed into the control unit.



How automatic monitoring systems work

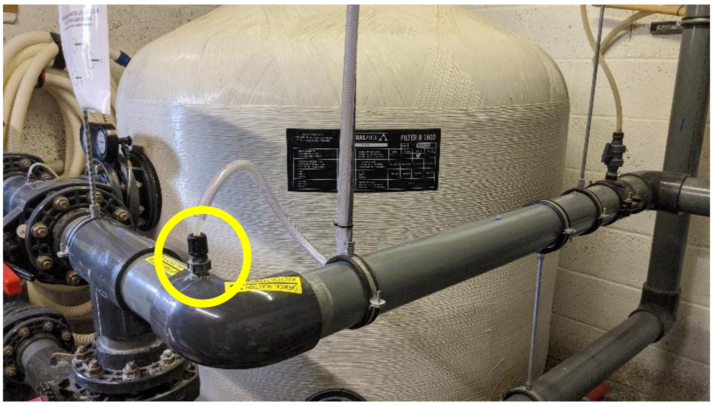
A sample of pool water is drawn from the pipework near the pump(s)

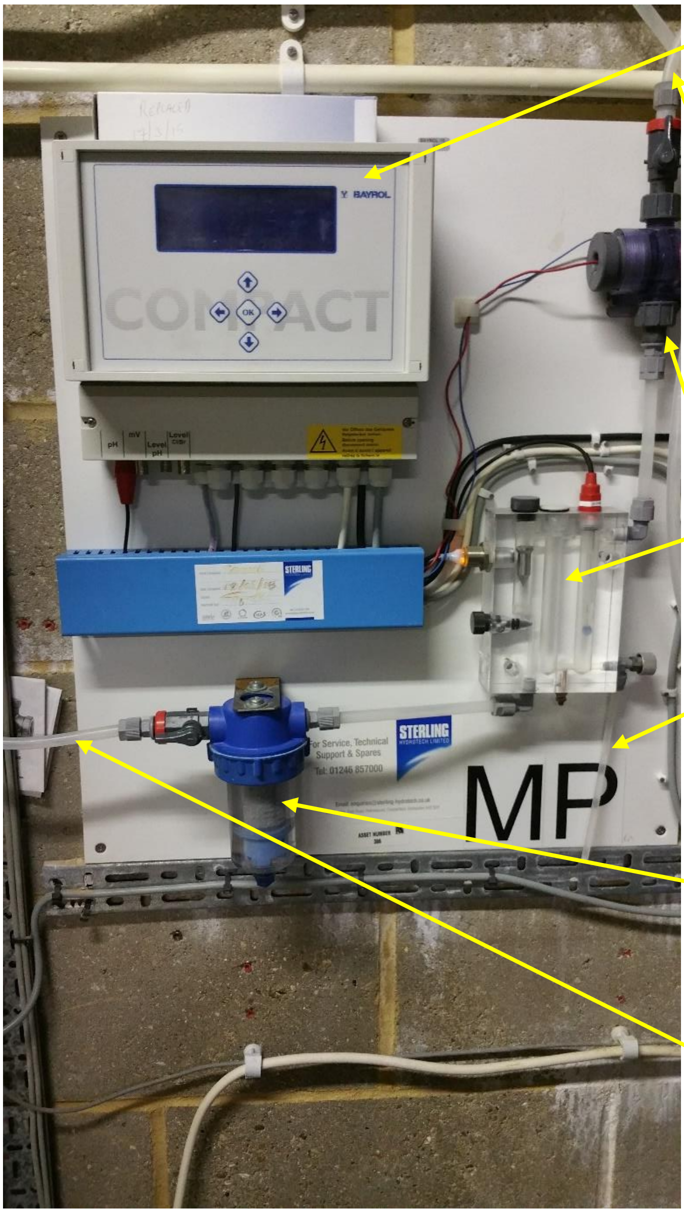
The sample goes to equipment that monitors the disinfectant and pH levels



The monitoring equipment controls the disinfectant and acid pumps

The disinfectant and acid is injected into the pipework (at separate injection points)





Control unit

Outgoing line. This usually loops back into the circulation system pipework, or to drainage

Probes (usually one for free chlorine and one for pH

Sample line valve for taking samples of pool water when carrying out control unit calibration

In-line filter. Needs to be cleaned or replaced regularly in order for the probes to provide accurate

Incoming feed. This feed is usually coming from the main circulation line in the vicinity of the circulation pump(s)

The sample line is usually taken from the circulation pipework in the plant room. In older pools, it may be taken form extract points in the pool wall.

It is recommended that a service contract is arranged for the ongoing service and maintenance of automatic dosing systems. As technology improves, these systems are becoming ever-more complicated and sophisticated. The following is a list of items that could be undertaken by a suitably competent member of staff:

Cleaning and calibration of the probes

Automatic monitoring systems vary in their levels of sophistication. Some are fairly simple: once the chemical pumps' stroke rate and speed have been set, pumping is activated/deactivated according to the discrepancy between the programmed set-point and the readings obtained from the sample. At the other end of the spectrum, there are controllers that are programmed to predict its response to readings in different circumstances and adjust accordingly in order to prevent under or over dosing, i.e. they are 'self-tuning'. They can also be connected to computer software to enable better communication in addition to being able to monitor and adjust from anywhere.

Systems also vary in their requirements for cleaning and/or calibration. Some systems will need neither as they are self-cleaning. Refer to the manufacturer's instructions to find out what type of on-going maintenance your system requires. If it does need to be cleaned and/or calibrated by the user, this usually involved isolating the incoming feed, disconnecting the leads from the control unit to the probes, unscrewing the probes and either dipping them into, or wiping them with a probe cleaning solution.

If calibration is being done at the same time, this usually involves navigating into the appropriate menu screen on the control unit and following the step-by-step instructions. For disinfectant calibration, a sample of pool water is taken from the sample line (not the swimming pool itself) and a free chlorine test is carried out using a DPD 1 tablet in the usual way. The control unit reading is then overwritten with the reading obtained from the DPD 1 test using the on-screen menus.

There are two different types of probes for the measurement and control of disinfectant; amperometric and redox. Amperometric probes work by measuring the hypochlorous acid in the sample. Redox probes work by measuring the oxidative power (ability to break down other substances) of the water.

For pH calibration, the probe is dipped into a solution with a known pH value (supplied by the manufacturers of the system) and then dipped into another solution with either a higher or lower pH value than the first solution. As with chlorine calibration, the operator is required to follow the manufacturer's instructions specific to the type of equipment and follow the on-screen instructions carefully. It is recommended that pool plant operators request that the service engineers provide them with a tutorial on the automatic control unit during one of their service visits. It is worth remembering that most probes require replacement on an annual frequency.

Cleaning/replacing the in-line filter

The in-line filter will get dirty, grimy and clogged up over time. This will then mean that the probes are no longer obtaining accurate chlorine and pH readings of the water. The filter should be isolated from the incoming feed and the assembly unscrewed so that the filter can be taken out and either cleaned or replaced with a fresh one (some in-line filters are only designed to be used once, then discarded). This task should be done as often as is necessary, but once per month is usually sufficient.

Adjusting control unit parameters

Operators may need to change the set-point parameters occasionally. This may be because there has been a contamination issue that requires the disinfectant levels to be at the top of the recommended range for a period (as would be the case following a liquid faecal release into the swimming pool). In these situations, it is useful for operators to know how to adjust the set-point parameters so that the system will adjust the dosing rate to achieve 5.00mg/l rather than the usual operating level of 2.00mg/l for example.

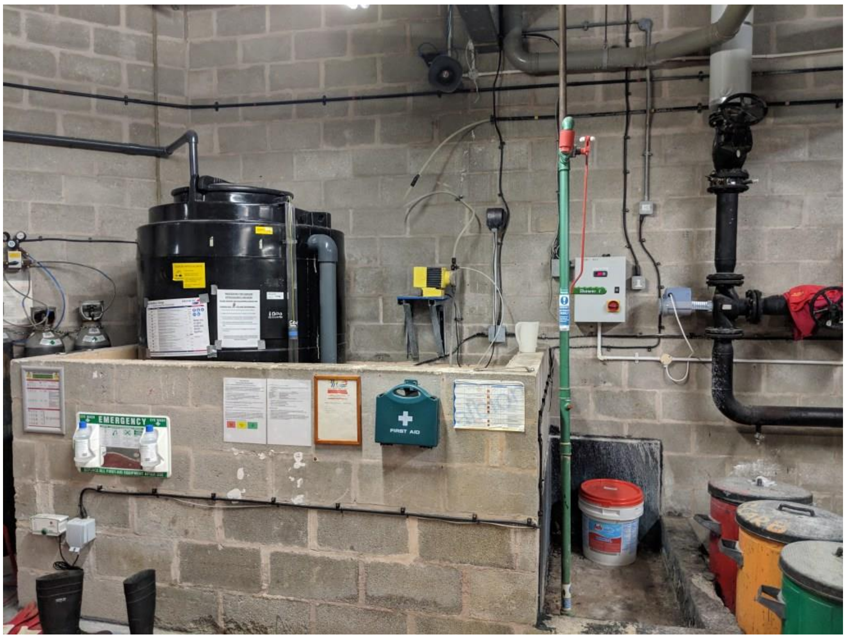
Carrying out routine inspections of the equipment

The entire dosing system should be inspected on a weekly frequency. The inspection should be recorded, and any issues dealt with as a priority. Things to look for include:

- Build-up of residue around joints and injection points
- Split chemical feed lines (or areas where a split would likely occur, such as twists and kinks etc.)
- Build-up of sediment in chemical feed lines and chemical storage tanks
- Missing or damaged sheathing of chemical feed lines

It should be noted that the above list is not exhaustive and additional items may need to be added, according to the nature and operation of the system.

Automatic Dosing Systems



Commercial swimming pools should have a system installed to automatically dose the disinfection, pH control and coagulation chemicals into the pool water circulation system.

Manually dosing chemicals (sometimes referred to as 'hand-dosing') is a hazardous activity that can be easily avoided by the installation, use and maintenance of such systems. Automatic dosing systems also provide a much more reliable level of control over the pool chlorine and pH levels.

Chemical dosing should be continuous, 24 hours a day. The automatic dosing system should be backed up by regular monitoring and verification.

Chemical tanks

Day tanks are vessels for holding the chemical solution, from where they are pumped into the circulation system, usually via an injector. They should be constructed from UV-stabilised polyethylene and ideally be fitted with:

- High and low level indicators and alarms
- Overflow pipe
- Water inlet from header tank
- Drain valve
- Agitator

If the plant is to be shut down for longer than 60 hours, valves in filling lines between the day and bulk tanks should not be closed, as decomposition products might otherwise build up. After such a shutdown, the whole of the dosing system should be flushed through gently with low-pressure water.

Chemical pumps

Following correct commissioning, calibration of the chemical pumps should not be necessary. However, it is important that a robust programme of monitoring, both automatic (via the probes integrated into the control panel) and manual (via the DPD1, DPD3 and phenol red reagent tests), is established and maintained.

Chemical pumps need to be appropriately specified. Under-specified pumps will not be able to cope demand and will under-dose, conversely, over-specified pumps may end up over-dosing chemicals.

A 450m3 pool wishing to introduce a free chlorine residual of 1.00 mg/l will need to dose approximately 450 ml of chlorine. If using a sodium hypochlorite solution of 10-15% strength chlorine, the amount of solution that will need to be pumped in will be approximately 3.0 – 4.5 litres, depending on the actual chlorine strength of the sodium hypochlorite. If using calcium hypochlorite disinfectant (appropriately prepared as a 3% solution), the amount of solution that will need to be pumped in will be considerably more, since the solution will have a lower concentration of chlorine (about 2%). The amount of solution to be pumped would be closer to 22.5 litres.

For illustrative purposes, if the amount of pollution being introduced into the pool is such that 1.00 mg/l of free chlorine would only last an hour, then the pump would need to be capable of pumping the quantities detailed above every hour. Of course, if the pollution levels are kept under good control, such that the chlorine demand is less, pump capacity specification can be reduced accordingly.

Following commissioning, calibration of the chemical pumps should not be necessary. However, it is important that a robust programme of monitoring, both automatic (via the probes integrated into the control panel) and manual (via the DPD1, DPD3 and phenol red reagent tests), is established and maintained.

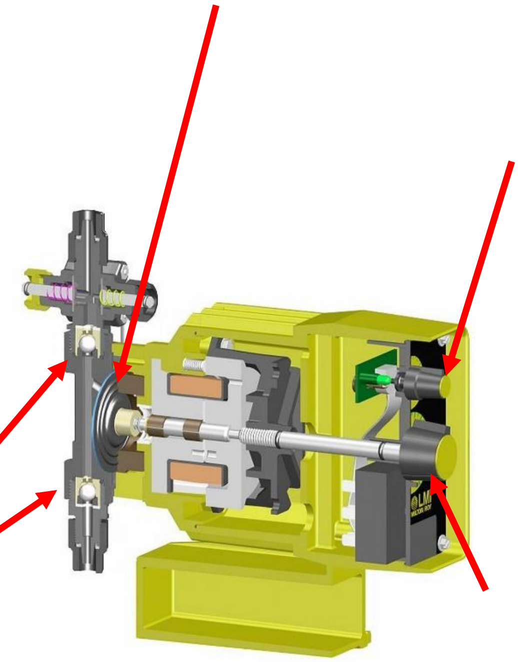
Multi-Function Valve

The black knob is the pressure relief. A 1/4 turn will open it and bleed any air locked in the pump.

By pulling both knobs (yellow and black) the discharge line will drain back to your supply tank.

Liquifram

Rubber diaphram that moves forwards and backwards, creating suction and pressure respectively. This draws solution up from the tank and along the discharge line.



Speed Knob

Adjusts the number of strokes per minute.

Stroke Knob

Adjusts the stroke length.

Check Valves

Small ceramic ball the prevents solution backflowing.

Circulation feeders

Pools that have the disinfectant pumped in from a chemical tank won't have these, but circulation feeders are items of equipment that some types of pools use to take dry chemicals and introduce them into the pool. They are mainly used for disinfectants. There are two types:

Erosion feeders

These are designed so that water flowing through them physically erodes material from a dry tablet; this subsequently dissolves in the water circulation. Calcium hypochlorite (see note 1 below) and trichlorinator (see note 2 below) feeders can be of this type.

Soaker feeders

These allow water to dissolve material from the tablet directly. Brominators (see note 3 below) are of this type.

Notes:

1. Calcium hypochlorite is a type of chlorine-based disinfectant that **DOES NOT** include cyanuric acid.
2. 'Trichlor' is a type of chlorine-based disinfectant that **DOES** include cyanuric acid.
3. Bromine is a type of disinfectant that is sometimes used instead of chlorine.

On most types of circulation feeder the water supply to the feeder is taken from the pressure side of the main circulation pumps and returns to the suction side of the pumps. The water passes through the feeder and is returned to the main circulation line. This has the advantage that it fails safe if the water circulation fails. Circulation feeders may be fitted with automatic controls, which will help to prevent overdosing.

Circulation feeder devices should only be used for the purpose, and chemicals, for which they were designed. Calcium hypochlorite, chlorinated isocyanurates and bromochlorodimethylhydantoin (BCDMH) all have specific feeders and it is vitally important that they are only used for the chemical for which they are designed.

WARNING!

Using the wrong chemical in a feeder can result in the formation of dangerous gases, fire or explosion. It is very important that chemicals are not mixed in closed containers/feeders as this may cause explosions.

Any closed vessels used for feeding chemicals need to be safeguarded against pressure accumulation and should be fitted with a pressure relief valve.

Circulation feeder devices should be emptied of chemicals if the pool circulation system is to be closed down for a period of time.

Inspection and maintenance

The entire dosing system should be inspected on a weekly frequency. The inspection should be recorded, and any issues dealt with as a priority. Things to look for include:

- Build-up of residue around joints and injection points

- Split chemical feed lines (or areas where a split would likely occur, such as twists and kinks etc.)
- Build-up of sediment in chemical feed lines and chemical storage tanks
- Missing or damaged sheathing of chemical feed lines

It should be noted that the above list is not exhaustive and additional items may need to be added, according to the nature and operation of the system.

Preparing chemicals for dosing

- Chemicals should always be added to water and never the other way around when preparing solutions.
- Non-liquid chemicals should be kept dry until dissolved in water.
- Calcium hypochlorite should be kept away from all other chemicals in its preparation for dosing.
- Calcium hypochlorite should be dissolved in water at a ratio of 1:33
- Sodium hypochlorite can be dosed at its delivery concentration (10-15%)
- If hydrochloric acid is not being dosed direct from a container, dilution should be introduced by filling the day tank with a known quantity of water, adding a known quantity of concentrate, and mixing thoroughly.
- Any sludge formed from the incomplete dissolving of chemicals should be cleared periodically.

Chemical Dosing Precautions

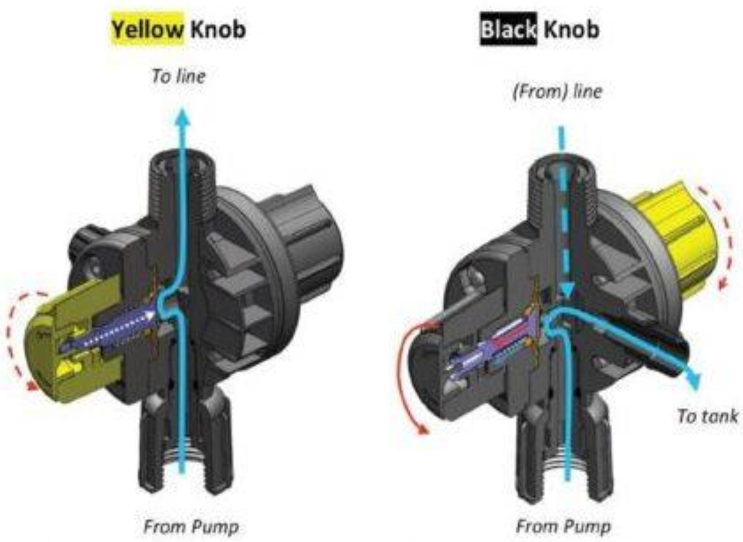
A flow measuring device capable of detecting a reduction or cessation of flow and interlocking this with the dosing pumps to prevent the continuation of dosing in the event of flow stoppage.

Most automatic dosing systems will have this as standard, but Pool Plant Operators should not assume they are fail-safe. Always check that the chemical dosing system has stopped when cutting power to the circulation pumps, e.g., when backwashing.

Siting the calcium/sodium hypochlorite and acid injection points as far apart as possible (preferably a minimum of 1 m); ideally, the hypochlorite injection point should be located before the filter and the acid dosing point after the filter and heat exchanger (although, this is not possible if using UV or ozone disinfection systems)

Ensuring that pressurised chemicals in the line are safely relieved before breaking the delivery line for maintenance work to be carried out.

Many systems have automatic pressure relief (see graphic). Check your system before attempting and disconnections.



Function	Action
Back-Pressure	Automatic
Anti-Siphon	Automatic
Burp	Turn Yellow

Function	Action
Pressure Relief	Automatic
Prime	Turn Black
Drain Line	Turn B & Y

Pipelines and injection points can become blocked by calcium deposits. Removal is usually carried out with acid; therefore, the pipes will need to have been flushed out, the acid then added to descale, flushed out again and released for maintenance.

Displaying notices warning of the risks of mixing calcium/sodium hypochlorite and acids, and the importance of maintaining pool water circulation during dosing.

Designing dosing lines so that they are protected from damage, and if possible, so that they cannot, inadvertently, be connected the wrong way round.

Manual/Hand Dosing

This is a hazardous activity and should not be performed by people who have not received the appropriate training. A proper risk assessment should be conducted before any manual dosing procedure is performed.

- **ALWAYS** wear the appropriate PPE.
- **ALWAYS** add the chemical to the water, **NEVER** add water to the chemical.
- **NEVER** mix a chemical with another chemical. Only ever mix with water.
- **NEVER** hand-dose chemicals into the swimming pool when occupied.
- **ALWAYS** allow time for thorough mixing and distribution of the chemical into all areas of the swimming pool water.

Increasing Chlorine

The following method will outline how to add a hypochlorite disinfectant to the swimming pool. If you're using a chlorinated isocyanurate disinfectant, follow the manufacturers' instructions as the method will be different.

We recommend using calcium hypochlorite granules for the purpose of hand-dosing. It's safer to store and handle than sodium hypochlorite.

Step 1. The first thing you need to do is calculate how many cubic metres of water you have in your swimming pool. Do this by multiplying the length by the width by the average depth. See the worked example below:

Length (20m) X Width (10m) X Average Depth (1.5m) = $300m^3$

Step 2. The next thing to do is calculate how much calcium hypochlorite granules you need to add in order to increase the free chlorine reading by 1mg/l. Do this by dividing the pool volume figure (from step 1.) by 0.65. The reason you need to divide by 0.65 is because calcium hypochlorite is typically only 65% chlorine. Some products are 70% chlorine, in which case you would divide by 0.70. See the worked example below:

$300m^3$ / 0.65 = 462

The figure obtained provides you with the amount of grams of calcium hypochlorite granules you need to add to the swimming pool in order to increase the free chlorine reading by 1.00mg/l.

Step 3. Use a set of kitchen scales to measure out 462g of calcium hypochlorite granules into a clear plastic jug.

Mark a clear line on the jug to indicate the level of calcium hypochlorite granules at 462g.

Step 4. Decide how much you need to increase the free chlorine reading by. For example, if you have zero free chlorine in the pool and you would normally operate at 2.00mg/l, then you need to increase by 2.00mg/l. This equates to the number of jugs of calcium hypochlorite granules you need to add to the swimming pool, i.e. 2 jugs.

Step 5. Now you need to add the granules to the swimming pool water. This can be done by carefully depositing the granules into either the overflow channel (in a deck-level pool) or the skimmer baskets (in a skimmer-basket pool). From here, the granules will be drawn into the balance tank (if there is one), or directly into the suction-side pipework of the circulation system.

Step 6. Allow some time for the granules to dissolve and make their way around the system and into all areas of the swimming pool. How long this will take will be dependent on a number of factors, such as the efficiency of the system hydraulics.

Step 7. Carry out a set of pool tests, taking the sample from a point in the swimming pool as far as possible from the inlets. This is to help you determine whether the chlorine you have introduced has been distributed to all areas of the swimming pool. If necessary, carry out further tests in order to be sure that all areas of the swimming pool have a sufficient level of disinfectant. Once you are satisfied of this, you can open the pool again to bathers.

Superchlorination

Superchlorination is not recommended as a routine or even occasional method of shock dosing to compensate for inadequacies in pool treatment. It is generally bad practice, and can generate unwelcome by-products. But if something has gone wrong – poor results from microbiological testing perhaps, or a catastrophic breakdown in treatment – it may be necessary to superchlorinate. It can also be a way to deal with contamination by diarrhoea, as some intestinal pathogens (eg Cryptosporidium) are resistant to normal levels of chlorine residual. In this case it may be needed where filtration is inadequate (high-rate for example, or regular coagulation not practised). Superchlorination can also deal with other organisms should the need arise.

Two pool parameters are needed as a starting point:

- the capacity of the pool in litres. Note: 1m^3 = 1,000 litres, 1 gallon = 4.54 litres
- the pool turnover period (the number of hours for a volume of water equivalent to the entire water volume of the pool to pass once through the water treatment plant).

The following chemicals and equipment will be required to undertake the procedure (which of course must include subsequent dechlorination):

- a suitable chlorine donor – sodium or calcium hypochlorite (not any cyanurate-based disinfectants as they are not effective enough)
- a dechlorinator – normally sodium thiosulphate pentahydrate
- a pool water test kit together with a dilution pot
- one or more clean 10-litre plastic buckets
- a cold water supply.

Operators must be confident that the pool plant (valves, seals etc) will withstand superchlorination.

Step 1. Close the pool to swimmers. If more than one pool uses the same filtration system, all pools will have to be closed to swimmers and superchlorinated. Do not allow anyone to enter the pool(s) until superchlorination and subsequent dechlorination is completed. Isolate automatic dosing controllers to avoid damage to the sensors.

Step 2. Raise the free chlorine concentration as required to deal with the problem, based on the chart below.

Reason for superchlorination	Concentration required mg/l	Contact time
Diarrhoea (possible contamination with Cryptosporidium	20	13 h
Algal growth	10	24 h
Legionella (spas)	50	16 h
Raised colony counts, coliforms, E. coli	5	1 h
Raised P aeruginosa	5	12 h

Step 3. Add the total amount of calcium hypochlorite to tap water in the bucket(s) until fully dissolved/mixed. Then spread evenly around the pool surrounds and mix well by agitation. Failure to dilute and spread evenly can result in the precipitation of hardness scale. Superchlorination will raise pH, so acid will be needed to reduce the pH value to 7.5 or less. In the case of contamination by diarrhoea ensure the water temperature is 25°C or higher.

Step 4. Ensure that the filtration system is operating while the water reaches and is maintained at the chlorine level required for superchlorination (see Table). With spas, all aerators, sprays etc. should be operating throughout.

Step 5. Test the free chlorine concentration 15 minutes after the initial addition to ensure that the correct concentration has been achieved (see Table). This may necessitate dilution of the sample with chlorine-free water to give an accurate measurement.

Step 6. Leave for the desired contact time (see Table). Check every two hours to ensure the concentration is being maintained. If necessary re-dose to reinstate the required free chlorine residual, again checking pH.

Step 7. Backwash the filter thoroughly after the given contact time and top up pool to the required water level. Be sure the backwash effluent is discharged directly to waste (and not to a septic tank or water course). As usual, rinse the filter before resuming filtration.

Decreasing Chlorine

It may be necessary to decrease the levels of chlorine on occasion and certainly following superchlorination. If you are going to be dumping a significant quality of swimming pool water for any reason, there would usually be a requirement to let the local water authority know and they would almost certainly require you to eliminate all traces of chlorine from the water before they granted permission to discharge (chlorine is harmful to aquatic organisms).

In normal operations, it would usually be better to bring the chlorine levels down by simply diluting the swimming pool with fresh water. This is safer and would contribute to less chemical pollution as well.

If you do need to decrease the chlorine quickly though, the chemical to use is sodium thiosulphate. The principle to bear in mind is that it takes 5g of sodium thiosulphate to neutralise 1g of chlorine. So if, for example, you had 10.00mg/l of chlorine in a 300m^3 pool, that equates to 3000g of chlorine in the pool, since each m^3 would have 10g of chlorine in it, and 300m^3 X 10g = 3000g. The simplest thing to do would be to calculate how much sodium thiosulphate you would need in order to decrease the free chlorine level by 1.00mg/l. See he worked example below:

300g chlorine X 5g sodium thiosulphate = 1500g

So, in this particular example of a 300m^3 pool, it would take 1500g of sodium thiosulphate to reduce the free chlorine level by 1.00mg/l/

From here, the same steps can be taken as given above in order to create a jug for the purposes of hand-dosing sodium thiosulphate (different jug – NEVER mix chemicals). Then, just add the required number of jugs in the same way as for adding calcium hypochlorite. So, in the example given, we would be adding 8 jugs of sodium thiosulphate in order to get the free chlorine down from 10.00mg/l to 2.00mg/l.

Increasing or Decreasing pH Value

The chemicals that can be used for hand-dosing of pH correctant are ***sodium bisulphate*** powder (dry acid) to reduce the pH and ***sodium carbonate*** (soda ash) to increase the pH. Hand-dosing pH correctants is more problematic. This is because it is difficult to calculate the amount of correctant to add in order to bring about the desired change in the pH due to the buffering effect of total alkalinity. The more buffered the water (due to higher total alkalinity), the more of a given pH correctant you would need to add in order to get to the desired pH value.

Increases pH

Decreases pH

Increasing or Decreasing Calcium Hardness

You need to try and keep your calcium hardness levels between 80 – 200mg/l in order to keep the water from eating away at the fabric of the pool construction (if calcium is too low) and depositing scale (if calcium is too high). If you want to decrease calcium hardness, the only option is to dilute with fresh water. To increase, the chemical to use is calcium chloride, usually supplied as a dry white powder.

To get calcium chloride in the pool, make up a solution by dissolving the calcium chloride in water and then distribute it as widely as possible over the surface of the pool. Dosage is 15 grams per cubic meter of pool volume to increase total alkalinity by 10.00 ppm

Increasing or Decreasing Total Alkalinity

You need to keep your total alkalinity reading between 80 – 200mg/l. Too high and you may experience pH lock, too low and you may experience pH bounce. The coagulant also needs at least 80mg/l to be effective. If you need to decrease levels, like for calcium hardness, the only option is to dilute with fresh water. If you need to increase levels, the chemical to use is sodium bicarbonate (NOT sodium carbonate).

To get the sodium bicarbonate in the pool, make up a solution by dissolving the sodium bicarbonate in cold water (not pool water) and then distribute it as widely as possible over the surface of the pool. Dosage is 17 grams per cubic meter of pool volume to increase total alkalinity by 10.00 ppm.

Control of Substances Hazardous to Health (COSHH)

Under the COSHH Regulations every employer has a responsibility to assess the risks associated with hazardous substances in the workplace and to take adequate steps to eliminate or control those risks. These Regulations cover the majority of swimming pool chemicals, hence the need for special care when choosing and using such materials. The Regulations also cover the risks arising from micro-organisms.

The first step is for the employer to assess the risk of each chemical. This must be carried out by a competent person - perhaps a member of the management team for a small, stand-alone pool, or often a specialist team in a multi-function local authority department. This process will also need to call on the experience and knowledge of others, for example the assessor will need to know about:

- which chemicals are used and how they are used (including storage)
- other chemicals on site - by reference to material safety data sheets, etc.
- site location in relation to the impact of a chemical accident
- staff training and competence in using chemicals

The next step under COSHH is to prevent or control exposure to hazardous substances. Prevention is obviously best. The pool operator will need to consider whether this can be achieved by substituting a less harmful substance, or one that is compatible with other chemicals on site. This may reduce the risk to health due to fire, explosion or the production of toxic gases.

Only where prevention is not reasonably practicable can the pool operator turn to other controls. Personal protective equipment should not be the first option. Instead, the risk must be reduced to acceptable limits by 'engineering' control measures such as using the least potentially harmful chemical that can achieve the purpose intended effectively and efficiently and by isolating or physically separating chemicals. These procedures must be systematically recorded to include:

- identification of the hazards
- identification of who might be harmed and how
- evaluation of the risks arising from the hazards, and decisions about precautions
- recording the findings
- regular review of the assessments and any necessary revisions.

The COSHH Regulations require suppliers of chemicals to provide a material safety data sheet (MSDS) for each chemical. It is also the installer's responsibility to provide relevant information on plant safety, etc - which may include MSDSs. There will need to be MSDSs for all the chemicals in the plant room including test reagent chemicals, cleaning chemicals, chemicals used in maintenance programmes, etc. The MSDS sheets are a key input into the COSHH risk assessment process. They should be considered as a valuable tool to help carry out thorough risk assessments.

The COSHH Regulations require that staff involved in the handling and use of chemicals should receive appropriate training and instruction. Even the most thorough arrangements to comply with the COSHH Regulations will fail unless all employees are aware of the risks associated with their work and how these risks can be avoided.

Only competent people should handle chemicals. Training will need to sufficient knowledge and understanding of the chemicals for staff to be alert to any changes affecting safety. Staff must be trained in, and the clear written procedures should be distributed to all employees involved in, the operation of plant or the handling of chemicals. The written procedures will need to include:

- safety requirements
- labelling and safety notices
- MSDSs (maintained on site) for all chemicals used
- information on delivery, storage, handling and use

The training for the safe operation and use of equipment and chemicals will need to:

- be related specifically to the operation and maintenance of the particular plant, hazards associated with it, and substances used. Employees' attention should be drawn to any manufacturers' instructions, and copies made conveniently available (eg secured to the plant itself)
- be given to enough employees to ensure that plant need never be operated by untrained staff
- include pool managers, to ensure they understand the functioning of the pool water system, including the plant and associated hazards, sufficiently to supervise safe operation
- include the use, care and maintenance of personal protective equipment
- require those who have been trained, to demonstrate that they can operate and maintain the plant safely

Pool operators will need to check that staff understand and follow all procedures and responsibilities. Monitoring and review of the effectiveness of arrangements should then follow. Details of actual training sessions will need to be recorded and reviewed. Information, instruction, and training are the essential requirements for all staff involved in the storage, handling, and use of swimming pool chemicals.

Routes of exposure

Hazardous substances can take many forms and include:

- chemicals
- products containing chemicals
- fumes
- dusts
- vapours
- mists
- nanotechnology
- gases

- biological agents (i.e., germs)

Ingestion

People transfer chemicals from their hands to their mouths by eating, smoking etc., without washing first.

Inhalation

Once breathed in, some substances can attack the nose, throat or lungs while others get into the body through the lungs and harm other parts of the body, e.g. the liver. For inhalation of chemicals, the casualty should be evacuated to a safe environment with fresh air to purge the lungs. If the casualty becomes unconscious, they should be placed into the recovery position and monitored, if they stop breathing, then artificial respiration should commence. Equipment should be used, such as a resuscitation face mask, to prevent the person administering the breaths from inhaling the gas themselves. The image opposite shows a particle respirator, which is not suitable for gas or vapour

Skin contact

Some substances damage skin, while others pass through it and damage other parts of the body. Skin can get contaminated: by direct contact with the substance, e.g. if you touch it or dip your hands in it; by splashing; by substances landing on the skin, e.g. airborne dust; or by contact with contaminated surfaces – this includes contact with contamination inside protective gloves. For contact with skin, it's important to flush the affected area with water. Drench showers should be provided close to chemical storage areas for this purpose. If much of the body is affected, it may be better to carefully lower the casualty into the swimming pool and remove any contaminated clothing.

Eyes

Some vapours, gases and dusts are irritating to eyes. Caustic fluid splashes can damage eyesight permanently. For contact with eyes, the chemical will need to be flushed out (whilst taking care to avoid the nose and risk inhalation). This should continue for at least 10 minutes. Eye wash stations should be provided close to chemical storage areas for this purpose.

Skin puncture

Health risks from skin puncture such as needle-stick injuries are rare but can involve infections or very harmful substances, (e.g. drugs).

Principles of control

The objective of the CoSHH Regulations is to prevent, or adequately control, exposures to substances hazardous to health so as to prevent ill health. It places a responsibility on employers to manage and minimise the risks from work activities. They must develop suitable and sufficient control measures and ways of maintaining them. To be effective in the long-term, control measures must be practical, workable and sustainable.

The principles of good practice are outlined in Schedule 2A of the CoSHH Regulations and should be applied in all circumstances and a combination of controls will often be necessary to best protect the health of employees. They are not rank ordered, the first is not more important than the last, although there is a logic to their overall order of presentation.

The principles of good practice are:

1. Design and operate processes and activities to minimise emission, release and spread of substances hazardous to health.
2. Consider all relevant routes of exposure.
3. Ensure control measures are proportionate to the health risk.
4. Choose the most effective and reliable control options to minimise the escape and spread of hazardous substances.
5. Where adequate control cannot be achieved by other means, provide, in combination with other control measures, suitable personal protective equipment (PPE).

6. Check and regularly review control measures to ensure their continuing effectiveness.
7. Inform and train all employees on the hazards and risks and the control measures developed to minimise the risks.
8. Ensure that the introduction of control measures does not increase the overall risk to health and safety.

Delivery of chemicals

Chemicals should be kept only in the containers in which they were received from the suppliers, or containers intended for that purpose and correctly marked with the safety information and product identity. The pool operator has a duty to use suitably marked containers that have been specifically designed to hold chemicals. Temporary unlabelled containers should not be used.

For bulk deliveries, a written delivery procedure should be agreed with the supplier, in accordance with hazard data sheets. Incompatible materials (eg acid and alkali), if delivered in the same vehicle, should be effectively segregated. Where sodium hypochlorite is delivered from a tanker to a day tank, the pipework, and connections, should be specific to that delivery, to prevent delivery hoses being incorrectly connected up. Loading points should be clearly labelled.

Suitably designed trolleys or similar equipment should be used to transport cylinders and heavy drums, which should be kept upright. It is strongly advised against rolling or dragging the containers. The transfer, whether by lifting or not, of materials into a bunded area needs care. Materials should not be transferred into containers not designed for that purpose. Empty containers should not be left on site or used for other purposes but be disposed of as soon as possible.

When chemicals are to be delivered, sufficient space for parking and manoeuvring should be provided close to the storage area. Precautions (eg supervision, warning signs, or barriers) should be taken as necessary to protect the public or employees who may have access to the delivery area.

Materials should be moved into storage as soon as possible, and never left unattended in a public area.

Storage of chemicals

Different types of chemicals should be effectively segregated in storage and use. This is particularly important where different disinfectants, or acids and disinfectants, may come into contact with each other and produce chlorine gas, fire or an explosion.

Each liquid chemical, whether in tanks or drums, should be in a separate bund; each bund should be capable of holding 110% of the chemical stored. Bunds must allow for puncture of the drums or tanks. Bunded areas should be clearly marked, giving details of the contents.

How NOT to do it…

Incompatible chemicals stored on top of each other.

Storage shelves clearly struggling with the weight.

Incompatible chemicals sited next to each other.

Calcium Hypochlorite container being used to store different substance.

Another example of repurposing original storage containers.

Sodium Bisulphate bags piled up and not protected from damage.

Safety data sheets (SDS)

A SDS will contain the information necessary to allow employers to do a risk assessment as required by the Control of Substances Hazardous to Health Regulations (COSHH). The SDS itself is not an assessment. However, it will describe the hazards helping employers assess the probability of those hazards arising in the workplace.

In emergency scenarios, it's likely that the casualty will need to go to hospital for further treatment. The medical staff will need to know more about the particular chemical that the casualty has been in contact with, so the relevant Safety Data Sheet must accompany the casualty to the hospital.

Handling Chemicals and Personal Protective Equipment (PPE)

The Personal Protective Equipment Regulations 1992 require pool operators to assess and provide necessary personal protective equipment (PPE) when performing certain tasks. It is recommended that pool operators take the advice of suppliers of equipment and chemicals as to what PPE is needed. The Safety Data Sheet will help determine the exposure controls/personal protection required.

Eye/face protection

Wear tight-fitting, chemical splash goggles or face shield.

Respiratory protection

If ventilation is inadequate, suitable respiratory protection must be worn. Wear a respirator fitted with the following cartridge: Particulate filter, type P2.

Employees who work with chemicals should have personal respirators (no sharing). The type of respirator, training, instructions and maintenance arrangements should be determined as part of the COSHH assessments.

Where chlorine gas or liquid bromine are used, or there is any risk of generating chlorine or bromine gas by accidental mixing of chemicals, it is important to provide precautions against exposure to toxic gases.

Suitable canister respirators should be kept available in or near plant rooms. In addition, canister respirators should be located in the immediate area where the leak may occur where they can be used by staff who may have to go into the area where a leak is apparent.

Canister respirators should only be used as a last resort. Where they are used, it is important that attention is paid to the manufacturer's instructions, in particular the limitations of the product, and that canisters are replaced shortly after the seal has been broken.

Hand protection

Use protective gloves. The most suitable glove should be chosen in consultation with the glove supplier/manufacturer, who can provide information about the breakthrough time of the glove material. Neoprene gloves are recommended.

Appropriate engineering controls

Provide adequate ventilation. Avoid inhalation of dust. Observe any occupational exposure limits for the product or ingredients.

Hygiene measures

Provide eyewash station and safety shower. Wash hands at the end of each work shift and before eating, smoking and using the toilet. Change work clothing daily before leaving workplace. When using do not eat, drink or smoke.

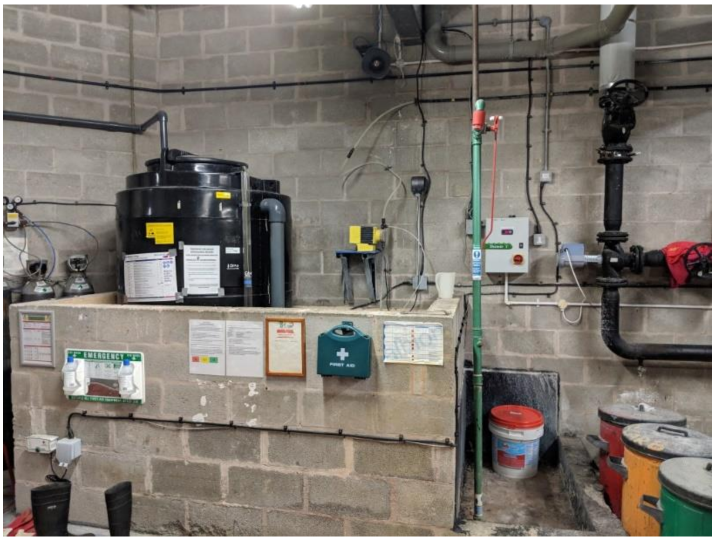
Chemical incidents

In any emergency a quick but calm reaction is necessary. Only personnel that know the product and have been trained to handle spills should be allowed in the area. Appropriate protective equipment should be worn when dealing with a spill.

- follow the emergency action plan
- protect the public and staff
- stop the leak and contain the spill
- clean up the spill and protect the environment

Leaks

Leak in the bulk storage tank, or its primary valve



Empty the tank as quickly as possible into other suitable containers – which might be intermediate bulk containers (IBCs). Call the supplier of the tank. Lowering the level of the product in the tank stops or reduces the amount leaking. Drum the material and return it to the supplier for recycling. Uncontaminated spillages may be able to be used in the pool.

Leaks in the piping or discharge hose

Close the primary valve at the base of the storage tank. In leaks in piping or hoses, closing a valve between the leak and the source of the material (tank) will minimise the loss.

Spills

Small spillages - If the spillage is under 45 litres, it can be diluted with large quantities of water and then if local regulations allow, run to drain with copious amounts of water. Otherwise, absorb and dispose of as above.

Large spillages - If the spillage is over 45 litres (10 gallons) immediately evacuate the area; remove sources of ignition; provide maximum ventilation. If the risk to people or environment is considerable, call the emergency services. Only personnel with proper respiratory and eye/skin protection should be permitted in the area.

Dam and absorb spillages with dry sand, soil or other inert material. Do not use combustible adsorbents such as sawdust. Then collect the absorbed material in containers, seal securely (with a vent) and deliver for disposal according to local regulations. Containers with collected absorbed material must be properly labelled with correct contents and hazard symbol.

Wash spillage site well with water and detergent; be aware of the potential for surfaces to become slippery. Continue to ventilate the site of the spillage.

Spillages or uncontrolled discharges into watercourse, drains or sewers must be notified immediately to the National Rivers Authority or other appropriate regulatory body.

Knowledge Test (check answers with tutor)

How often should automatic monitoring and dosing systems be inspected for issues such as:

Build-up of residue around joints and injection points
Split chemical feed lines (or areas where a split would likely occur, such as twists and kinks etc.)
Build-up of sediment in chemical feed lines and chemical storage tanks
Missing or damaged sheathing of chemical feed lines

- ○ Every 6 months
- ○ Monthly
- ○ Weekly

It’s safe to mix chemicals as long as water is used to dilute the solution.

- ○ False
- ○ True

What chemical is used to DECREASE chlorine in swimming pools?

- ○ Sodium Thiosulphate

○ Sodium Bisulphate

○ Sodium Hypochlorite

What is a Safety Data Sheet (SDS)?

○ A risk assessment as required by the Control of Substances Hazardous to Health Regulations (COSHH).

○ A document that contains the information necessary to allow employers to do a risk assessment.

Is Calcium Hypochlorite acidic or alkaline?

○ Alkaline

○ Acidic

When preparing chemical solutions, the water should always be added to the chemical to be diluted, not the other way round.

○ False

○ True

Imagine you are the Pool Plant Operator of a swimming pool with a volume of 250 cubic metres. The automatic monitoring and dosing system has developed a fault and you are required to manually dose some disinfectant.

The current free chlorine reading is 0 PPM.
The disinfectant you are using is calcium hypochlorite at 65% chlorine strength.

How many grams of calcium hypochlorite would you need to dose in order to increase the free chlorine to 2 PPM?

Fill in the blanks below with either ALWAYS or NEVER.

Manual doing is a hazardous activity and should not be performed by people who have not received the appropriate training. A proper risk assessment should be conducted before any manual dosing procedure is performed.

______ wear the appropriate PPE.

______ add the chemical to the water, ______ add water to the chemical.

______ mix a chemical with another chemical. Only ever mix with water.

______ hand-dose chemicals into the swimming pool when occupied.

______ allow time for thorough mixing and distribution of the chemical into all areas of the swimming pool water.

Which of these chemicals would be used as a disinfectant?

- ○ Sodium Bisulphate
- ○ Sodium Hypochlorite
- ○ Polyaluminium Chloride

09. Other Types of Pool

On completion of this lesson, you'll understand the issues that affect pools other than the traditional commercial swimming pool. How and why they need to operate slightly differently in some circumstances.

Spa Pools

Definition of a spa pool

A spa pool is designed for sitting or lying in up to the neck, not for swimming. The body of water could be either self-contained or integrated with a larger swimming pool. It is not drained, cleaned or refilled after each user, but after a number of users or a maximum period of time. Spa pools contain water heated to around 37°C and have water-jet circulation with or without air bubbles.

Legionella risk factors

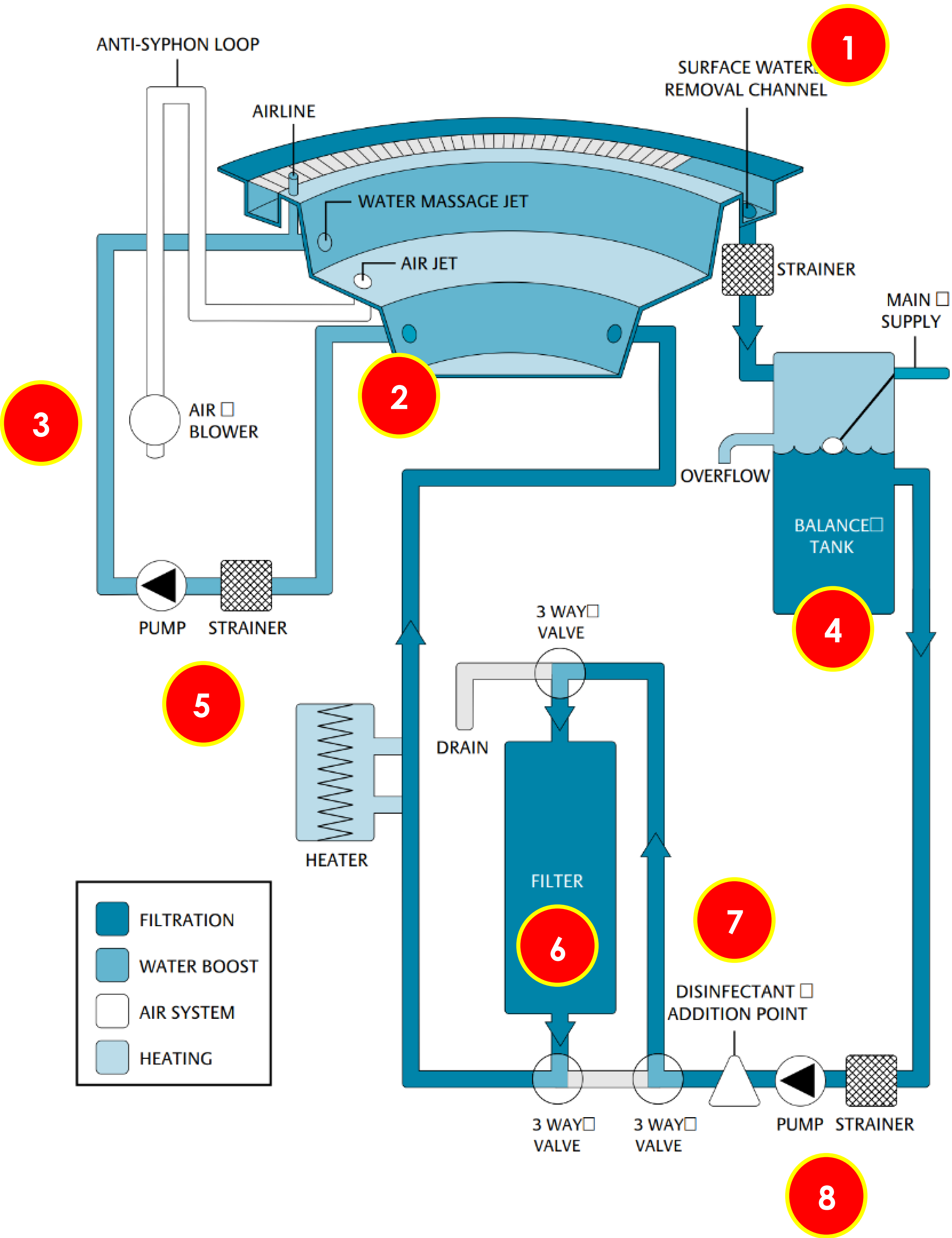
There have been several legionella outbreaks, including fatalities, linked to spa-pool systems in leisure centres, hotels, holiday homes, on cruise ships and on display. These systems pose a reasonably foreseeable risk as they have environmental conditions that could potentially allow and support growth and dispersion of legionella and other infectious agents

The following are significant risk factors:

- water is stored or recirculated
- water temperature in all or part of the system is between 20–45 °C
- these systems can support microbial growth
- water droplets are produced and dispersed as aerosols
- there is the potential for exposure to any contaminated aerosols

Spa pool components and functions

Typical sites for commercial spa pools include hotels, health clubs, beauty salons, gymnasia, sports centres and clubs, swimming pool complexes, and holiday camps. A spa pool in such a location is considered commercial even if payment for use is not required. A spa pool installed in a hotel bedroom or holiday home or rented out to domestic dwellings for parties etc. should also be managed as a commercial spa pool.



1 Intensively used spa pools should be designed with a surface draw off of at least 80% of the circulation volume. This is achieved by the installation of a level deck system. Skimmers are not considered to be suitable for heavily used commercial spa pool application. Pumps should be sized to provide a turnover of 6 minutes.

Water within the spa pool should continually overflow into the deck channel, which then returns to the balance tank.

Clean overflow channels and skimmers daily – at end of the day/user period.

2 There is a risk of suction entanglement and trapping hair or body parts in the spa-pool inlets, outlets and grilles. The risk should be assessed and appropriate control measures used to reduce it, for example by using design features and clearly displayed information to users.

All suction outlets from the spa pool should be duplicated to reduce the entrapment of hair or any part of the bathers' bodies and connected to more than one fitting. Fittings are also of an anti-vortex design for the same reason. It is not recommended that separate suction pipes be run to the plant room and valved but, if they are, it is essential that all suction valves are open while the pump is running to avoid deadlegs.

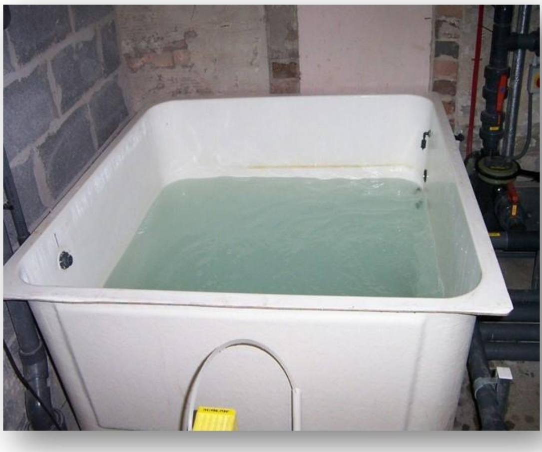
All suction outlets should be duplicated and connected to more than one fitting, and the fittings should be of an anti-vortex design to reduce the risk of entrapment. The main circulation system will draw from the balance tank only – hence, no outlets, but the secondary circulation system for the water jets will typically draw water from the base area of the spa pool via outlets that can have particularly high water velocities).

3 Most spa pools also have an air massage system consisting of a series of air holes or injector nozzles in the floor and seats. An air blower delivers air to these outlets and is operated in the same manner as the booster jets. The air intake must be from a satisfactory source – warm air may be required.

The air holes in injector nozzles and associated pipework are often traditionally buried in the insulation and inaccessible. When the air blower system is not operating water will fill the air system up to the level of the water in the spa pool. Since there is no water circulation through the air system the disinfectant can rapidly become depleted. Condensation will also form in any pipework above the water level, encouraging the growth of biofilms and fungi. The air system can therefore become inadequately disinfected and act as a focus for the growth of infectious agents that are then difficult or virtually impossible to disinfect and remove adequately. This pipework should be designed to be readily demountable and accessible for cleaning and disinfection.

4

A tank fitted in circulation system of overflow spas to balance water displaced by bathers and to provide additional water volume in heavy-use situations, to maintain a constant level in a commercial-type spa.



Drain and clean balance tank at least twice per year based on risk assessment and weekly visual checks.

5

The jet or booster pump takes its water from the spa pool and delivers it directly back to the jets. The action of the water through the venturi in the jet creates a suction, which, when the air controllers are open, allows air to mix with the water to increase the massage effect. The air controllers may be sited on the spa pool or valved in the plant room. The pump is operated by an air switch near the spa pool or remotely by the attendant, an automatic timer should shut the system down after a short time, usually ten or fifteen minutes.

Ideally the pipework and certainly the jets should be readily demountable (the latter from inside the spa) and accessible for cleaning and disinfection.

6

Filters for commercial use will either be permanent sand filters or diatomaceous earth. When using sand filters care must be taken to ensure that sufficient water, whether from the spa pool, balance tank or both, is available for adequate backwashing as prescribed by the manufacturer. Diatomaceous earth filters require less backwashing than sand filters but managers should be aware that these filters require the regular replenishment of diatomaceous earth after backwashing, which can increase the maintenance and running costs. A simple means of adding the diatomaceous earth should be installed. It is not ideal to add this via the balance tank. Simple paper cartridge filters are not recommended for commercial spa pools, but are suitable for use in domestic spa pools. Highly efficient cartridge filters are now being produced for commercial use – see specialist advice for further information. Filter pumps will have a course strainer basket which must be examined daily, cleaned if necessary, and in any event cleaned at least once a week.

Sand filters in commercial spa pools should be backwashed on a daily basis. Filters should always be backwashed before the pressure rises above normal clean operating pressure by 0.35 bar. Diatomaceous earth filters should be backwashed and recharged according to manufacturer's instructions.

7 A variety of disinfectants (e.g. chlorine and bromine releasing chemicals) are used in spa pools. The spa pools may either be treated individually or as part of a combined swimming pool water treatment system of the type found in leisure complexes.

The nature of the incoming mains water supply needs to be taken into consideration before a selection of the disinfectant can be made. Various features, e.g. the elevated temperatures, amount of sunlight present, high turbulence caused by the hydrotherapy jets and/or aeration, and high organic loading due to heavy use patterns, may influence the maintenance of disinfectant levels. Where chlorinating disinfectants are used a free chlorine residual of 3-5 mg/l should be maintained in the spa pool water and for bromine 4-6 mg/l of total active bromine. The efficacy of the disinfectant is directly related to the pH of the water. These values are only correct for water at pH 7.

In commercial spa pools the introduction of water treatment chemicals must be automatically controlled. Hand dosing should NOT be used except in emergencies such as plant failure or for shock treatment.

The process of disinfection using a chlorinating agent results in the formation of free and combined chlorine. Combined chlorine has slow and little disinfectant effect. It is formed by the reaction of free chlorine with organic materials arising from bather pollution e.g. urine and perspiration. The efficiency of the disinfection system to cope with the bather load is reflected by the concentration of combined chlorine. The ideal combined chlorine concentration is 0mg/l, however, a concentration of less than 1mg/l is normally considered acceptable. Above this level irritation to the mucous membranes of the eyes and throat may occur.

Disinfection using a brominated chemical results in combined bromine being formed as the predominant and effective disinfectant. Free and combined bromines are not usually differentiated between when monitoring the spa pool water disinfectant concentration, since combined bromine is still an effective disinfectant.

For spa pools that form an integral part of a leisure pool system, where chlorinating disinfectants are used in conjunction with ozone the residual disinfectant concentration required in the spa pool water will be dependent on spa pool design and attaining satisfactory microbiological results.

The microbiological results should indicate low colony counts and the absence of Pseudomonas aeruginosa and Legionella bacteria. Problems have been encountered with microbiological contamination of the deozonising filter media, e.g. carbon. Low residual disinfection concentration can encourage microbiological growth, both in the spa pool water and subsequently in the filter media. Care must therefore be taken to ensure that a satisfactory residual disinfectant concentration is attained which will not permit microbial growth. In addition it may be necessary to backwash activated carbon or hydroanthracite filters with water chlorinated to 10mg/l by addition of chlorine to the strainer basket or better still through the balance tank.

No disinfectant will work effectively if there is an accumulation of organic matter in the strainers, filters and pipework etc.

8 With effective skimming and filtration systems, there should be a maximum water turnover time of 6 minutes for commercial spa pools. The turnover time is the time taken for the entire spa pool water volume to pass through the filters and treatment plant and back to the spa pool.

Bather loads and dilution rates

The design bathing load is the maximum number of bathers who use the spa pool in any one-hour, each hour consisting of three 15 minute bathing sessions followed by a five-minute rest period. The design bather load should be approximately 10x the m^3 volume of water in the spa. A full risk assessment is needed to confirm that this bather load gives satisfactory water quality.

For stand-alone commercial spas, pool water should be replaced with fresh water when the number of bathers = 100 x the water capacity measured in m^3.

For spa pools that are incorporated with the swimming pool water treatment system dilutions of pollutants is much greater and the recommended standard for swimming pools of 30 litres per bather per day should be applied to the whole swimming pool and spa pool system combined.

Operational Actions and Frequencies for Spas

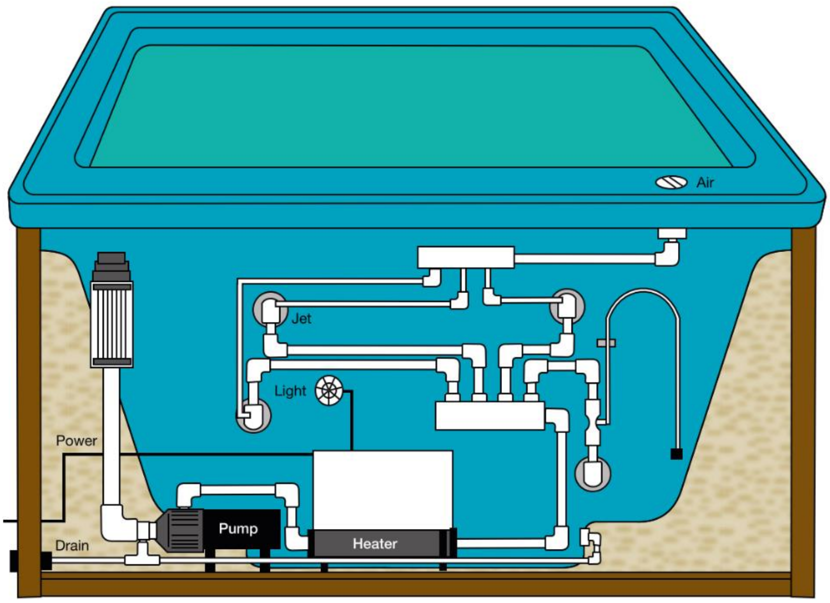
Operational actions	Typical frequencies	
	Commercial-type spa pools (high bather load)	Domestic-type spa pools and hot tubs
Check water clarity	Daily at opening and every two hours thereafter	At least twice daily depending on risk assessment and usage
Check if dosing system is working	Daily at opening	Daily
Check chemical reservoir level	Daily at opening	Daily where appropriate
Determine pH value, and residual disinfectant	Daily at opening and every two hours thereafter	At least twice daily depending on risk assessment and usage
Determine TDS	Daily	-
Clean the water-line	Daily – at end of the day/ user period with a fresh damp cloth using sodium bicarbonate (sodium hydrogen carbonate)	Check daily and clean as appropriate but as a minimum at water replacement
Clean overflow channels and skimmers	Daily – at end of the day/ user period	Check daily and clean as appropriate but as a minimum at water replacement
Clean spa-pool surround	Daily – at end of the day/ user period	Check daily and clean as appropriate but as a minimum at water replacement
Backwash filter	Daily – at the end of the day/user period	-
Replace cartridge filter with a cleaned cartridge	-	At water replacement
Inspect strainers and grilles	Daily	At water replacement
Record incidents	Daily	As appropriate
Check any automatic systems are operating correctly	Daily	Daily, where fitted
Drain spa pool, clean whole system including strainers and refill	Daily to weekly based on risk assessment	Between each group of users or at least weekly, whichever is shorter
Drain and clean balance tank	At least twice per year based on risk assessment and weekly visual checks	-
Inspect accessible pipework and jets and clean as necessary	Weekly	Weekly
Disinfect flexible hoses	Monthly	Monthly
Microbiological testing	Monthly for ACC, coliforms, *E coli*, *P aeruginosa* and quarterly for legionella	Monthly for ACC, coliforms, *E coli*, *P aeruginosa* and quarterly for legionella
Clean input air filter	Monthly	Monthly
Full chemical test dependent on water quality	Monthly or as determined by risk assessment	As determined by risk assessment
Disinfectant/pH controller – clean electrode and check calibration	Monthly or according to manufacturers' instructions	Monthly, where fitted, or according to manufacturers' instructions
Check effectiveness of filtration	Quarterly	-
Check, clean, disinfect and dry filter cartridge	-	Between each group of users or weekly, whichever is shorter
Clean and disinfect airlines	Quarterly	Weekly where appropriate
Check sand filter	Quarterly check and annual sand replacement	-

Hot Tubs

Definition of a hot tub

A hot tub is a self-contained factory-built unit generally designed for a small number of people to sit or lie in, and not for swimming or total body immersion. They are for use by a small, discrete group of people at any one time and are typically:

- of either a rigid or inflatable/foam-filled structure with freeboard and skimmer;
- systems where the water should be changed after each rental/week, whichever is the shorter;
- disinfected using bromine or chlorine through the use of an inline disinfectant feeder.



Hot tubs contain water heated usually to between 30 and 40°C, which is filtered and chemically disinfected. They have air-jet circulation with or without air-induction bubbles and can be sited indoors or outdoors. Such systems can produce aerosols by means of air jets or similar devices. A hot tub is usually drained, cleaned or refilled after a number of bathers or a maximum period of time rather than after each bather.

These spa pools are not suitable for medium or large-scale business use (i.e. large numbers of casual bathers and/or unrelated groups), or for commercial activity, as design features and systems for control are unlikely to be sufficient to cope with user demand.

Hot tubs used as part of a business activity (e.g. in a holiday park rental unit or hotel bedroom(s) with their own dedicated spa, or as part of a rental agreement for a single family or group use) are subject to the general duties under the HSW Act. There is a legal requirement for these systems to be managed and controlled in proportion to the risk and the risk assessment should consider the type of pool and its use.

"We have a hot tub at our holiday rental business. Does Health & Safety law still apply?"	Hot tubs used as part of a business activity (e.g. in a holiday park rental unit or hotel bedroom(s) with their own dedicated spa, or as part of a rental agreement for a single family or group use) are subject to the general duties under the Health & Safety at Work Act. There is a legal requirement for these systems to be managed and controlled in proportion to the risk and the risk assessment should consider the type of pool and its use.

"Our hot tub is for display only. What's the risk?"	There have been significant outbreaks associated with spa pools on display. Where a domestic-type pool is on display at a showroom or exhibition, the design bather load would not apply to the risk assessment as the pool should be displayed empty of water and there would be no intended bather use. However, if it is filled, the risks posed to individuals who work with or pass in close proximity to the spa pool must be considered and must be treated and controlled. There have been several outbreaks of Legionnaires' disease, including fatalities, linked to hot tubs on display and in rented holiday accommodation. Hot tubs pose a recognised and predictable risk as they have environmental conditions that allow and support growth and dispersion of Legionella and other infectious agents as they have: • water which is stored or recirculated; • a water temperature in all or part of the system between 30 and 45°C; • a high bather load, increasing the nutrient content for microorganisms; • water droplets produced close to the users' faces and dispersed as aerosols which may infect individuals in the surrounding environment.

Hot tub bather loads

Design bather load is crucial as part of the risk assessment to achieve adequate control. There are circumstances where a domestic-type hot tub would be unsuitable. Examples would be; high bather loads, continuous bather use, or where several accommodation units have shared access to a hot tub. Commercial-type spa pools should be used instead.

Where the use of a commercial-type spa pool is not possible or practicable, the risk assessment must consider the bather load, the characteristics of the hot tub, and the control measures required to effectively manage the risk.

Commissioning

The hot tub should be thoroughly tested to confirm its functional safety and fitness for its intended purpose before being used. The procedure and results should be fully documented.

The process must be carried out by competent people in a logical and defined manner and in full compliance with the instructions from the manufacturer.

The precautions to control the risk of exposure to Legionella and other infectious agents during normal operation also apply to the commissioning process.

A hot tub system may harbour microbial contamination from leak testing before leaving the manufacturer or supplier. This risk must be assessed, and all components cleaned and disinfected as part of the commissioning process.

Commissioning should include:

- water disinfection to reduce microbial growth, typically with 50 ppm chlorine for at least one hour, with the pH kept as near to 7.0 as possible during this period

- evidence that all appropriate regulatory and safety standards have been met, e.g. water supply and fittings, electrical wiring, and building regulations

- a comprehensive functional water test to ensure the hot tub system operates correctly

- chemical and bacteriological analysis of the water to ensure operating parameters are achievable and being maintained.

Laying-up

If a hot tub is to be left empty and unused, it should be shock dosed with chlorine at 50mg/l for 1 hour at pH 7.0-7.4 immediately before draining and then the full commissioning process should be carried out immediately before making ready for use.

Hydrotherapy Pools

Definition of hydrotherapy pools

Hydrotherapy pools are those that are used by people with special needs. They are similar to teaching pools in terms of size, but usually operate at a higher temperature (around 34° C). There is an increased risk of faecal contamination of a hydrotherapy pool and this creates an increased risk from infection by organisms such as e coli and cryptosporidia.

The following precautions should be taken:

a) The pool water should undergo microbiological testing every week (rather than every month, as for other types of pool)
b) Pre-swim showering should be tightly controlled
c) Hydrotherapy pools should not be used for swimming lesson schemes unless a suitable and sufficient risk assessment has been carried out by a competent person and indicates that the risk to health is low

Knowledge Test (check answers with tutor)

How often should a spa pool have the water tested for the presence of legionella bacteria?

- Quarterly
- Monthly
- Weekly

Fill in the blanks below.

The design bathing load is the maximum number of bathers who use the spa pool in any one-hour, each hour consisting of three ______ minute bathing sessions followed by a five-minute rest period. The design bather load should be approximately ______ times the capacity of water in the spa pool system when measured in cubic metres.

Hot tubs used as part of business activity (e.g. in a holiday park rental unit or hotel bedroom(s) with their own dedicated spa, or as part of a rental agreement for a single family or group use) are subject to the same general duties under the Health and Safety at Work Act as any other type of commercial pool?

- False
- True

How often should microbiological tests be carried out on a hydrotherapy pool?

- Weekly
- Monthly
- Quarterly

What is the correct free chlorine residual for commercial spa pools?

- 4.00 – 6.00 mg/l
- 3.00 – 5.00 mg/l
- 0.50 – 2.00 mg/l

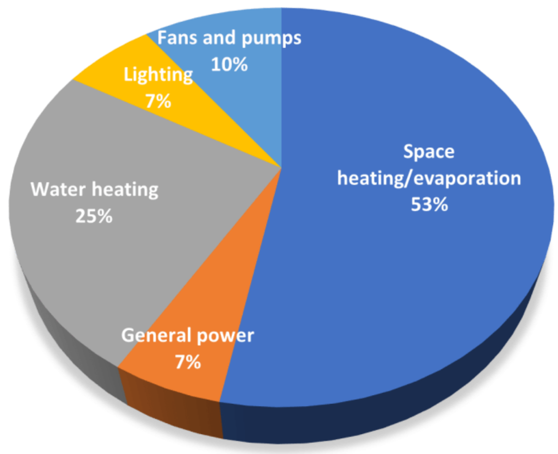
10. Air Handling and Energy Efficiency

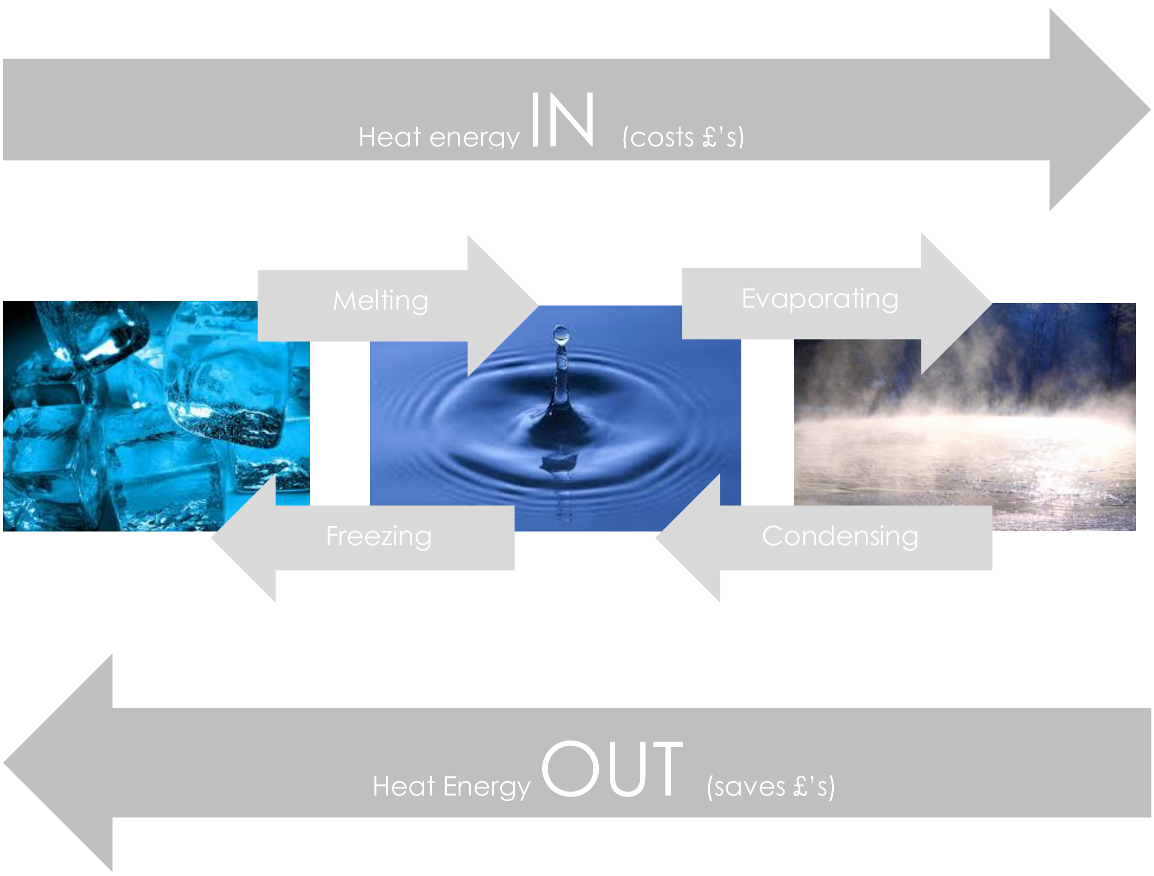
On completion of this lesson, you'll understand how energy is utilised within a swimming pool building and be able to use this understanding to make significant cost savings on energy bills.

Latent Heat

In a swimming pool, air handling is the single biggest energy cost. So big that it can be more than the combined cost of all the other energy being used by the facility!

What needs to be understood is the relationship between heat energy and what happens when a substance changes phase from solid to liquid, to gas (and vice-versa).

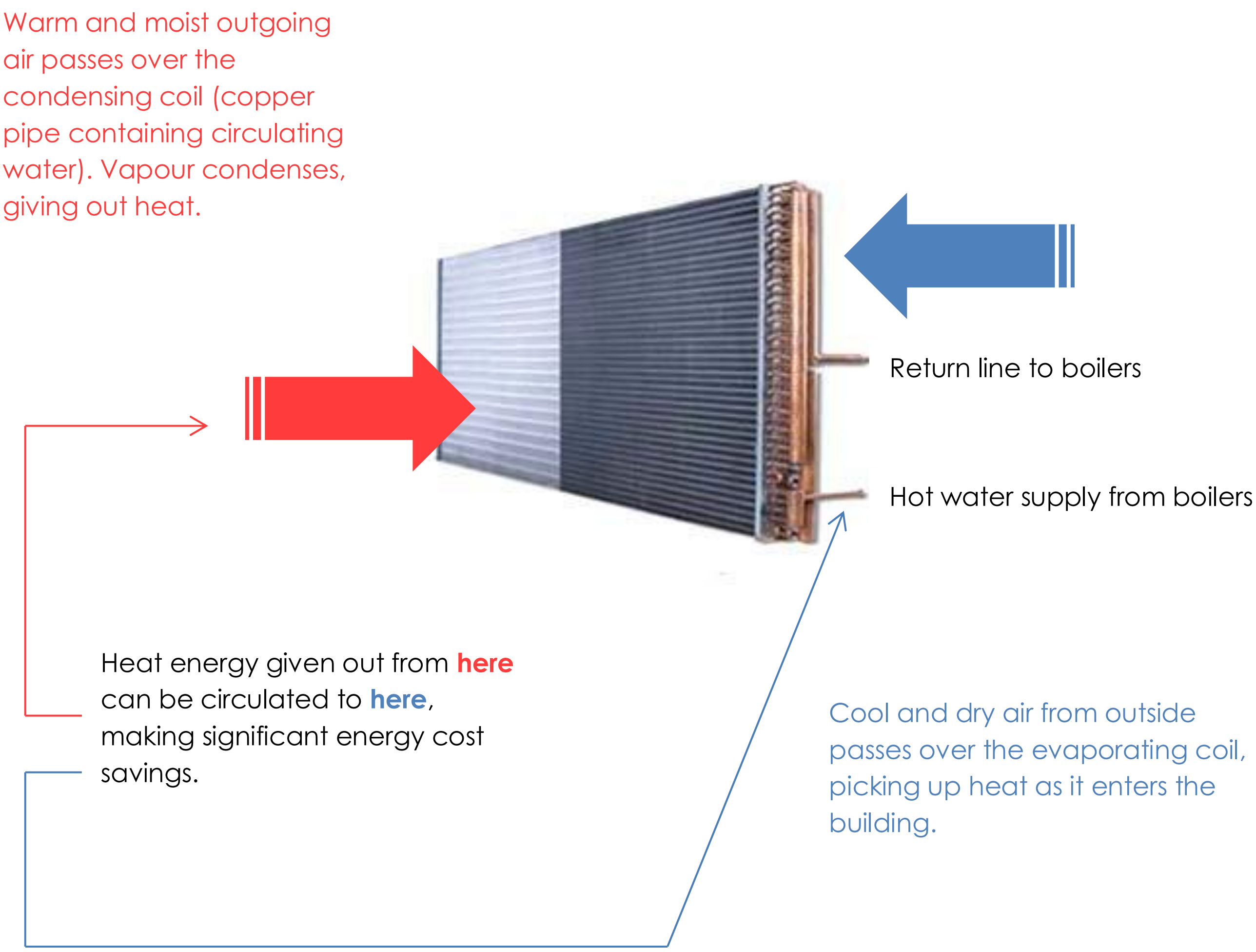




If you want to turn ice into water (melting), you need to apply heat. If you want to turn water into steam (evaporating), again you need to apply heat. Conversely, when water freezes, heat energy is given out. This is called latent heat. Heat is also given out when steam condenses into water.

How money can be saved or wasted by latent heat

Air handling units capitalise on this concept by passing outgoing air (which is warm and moist) through a condensing coil. As the air passes through the condensing coil, the water that is contained within the air in the form of vapour condenses onto the coil. As discussed, this process gives out latent heat energy and this heat can be redirected (to the evaporating coil on the incoming air supply for example).

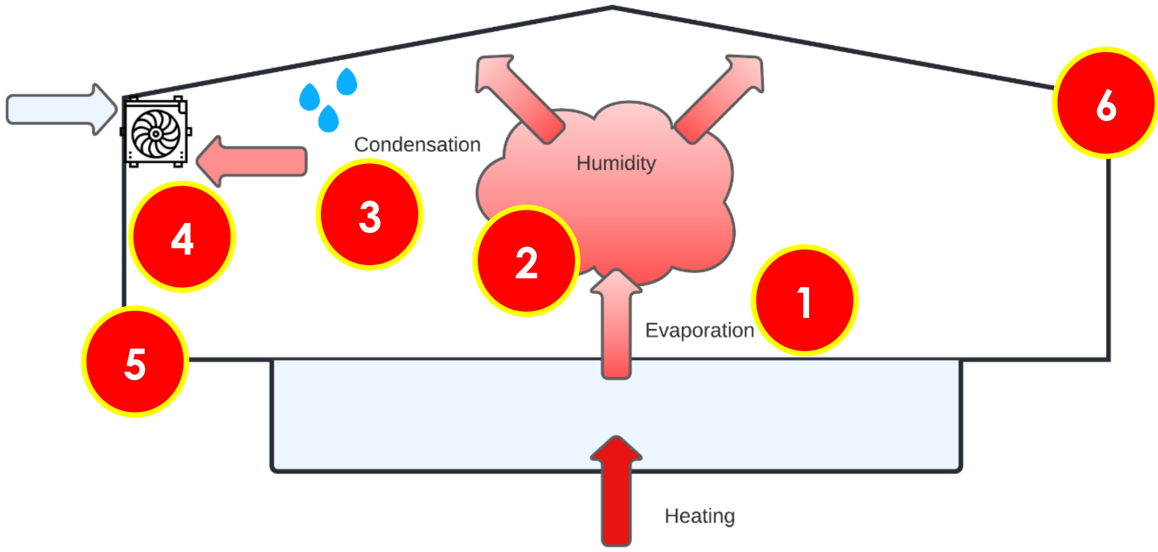


The exchange of outgoing air and incoming air must take place via the air handling system in order to be able to make the exchange of heat energy. If windows and doors are left open on poolside, the opportunity to 'harvest' the heat energy will be lost.

Evaporation, Condensation and Relative Humidity

How environmental conditions affect energy usage and the building structure

The physics involved in evaporation, condensation and humidity can get pretty complex but a general understanding can pay off because it can help manage these factors to significantly reduce operating costs.



1

Evaporation

It takes approx. 80 calories of heat to increase the temperature of 1 gram of water by 1 degrees Celcius. This is called 'sensible heat'.

To vaporize (evaporate) the same amount of water requires a whopping 540 calories of heat. This is called 'latent heat' and was discussed in the previous topic.

Where does this heat energy come from? Basically - the pool water. Obviously, heat input is required to increase the water temperature, but as evaporation occurs, so does heat loss from the pool water, which has to be replaced by the heat provided by the pools heating system, which can end up being very costly.

Pool covers can help to reduce costs by minimising the rate of evaporation taking place at the water surface.

Air movement at the pool surface encourages evaporation to occur. Therefore, it is better to avoid deliberate air movement such as directing air onto the pool from jets built into the ductwork if other comfort requirements can be met without constantly refreshing the air at the pool surface. Angle jets towards the sides of the pool hall away from the surface of the water.

2

Humidity

Humidity is the amount of water vapour in the air. 'Relative humidity' is the amount of water vapour contained in the air expressed as a percentage of the maximum amount of vapour the air could contain at that temperature. Air that is at 100% relative humidity is said to be at the 'saturation point'. At this point, it is physically impossible for the air to contain any more moisture than it already has.

If you are standing in an environment that is at 100% relative humidity and it is hot or you are engaged in physical exertion, your body's cooling mechanism (sweating) will not work. The body will continue to produce sweat, but if the air next to the skin cannot accept any more moisture, the sweat won't evaporate, your body temperature will, therefore, continue to rise. This can lead to a very uncomfortable muggy feeling and can even cause heat exhaustion leading to heat stroke in extreme circumstances.

Most swimming pool halls and associated air handling systems are designed to provide air at 50% – 70% relative humidity. That means the air is capable of accepting moisture and evaporation will occur. This is good for environmental comfort, but it does cost money because of the evaporation that will also be occurring from the swimming pool water surface.

3

Condensation

Condensation occurs when a substance (in this case, water) changes phase from gas to liquid. When the water vapour in the air condenses into liquid water and forms a film on surfaces it will start to attack the fabric of the building and lead to expensive repair bills further down the road.

For the pool operator, the objective is to keep this condensation to a minimum. This can be achieved by being aware of the temperature at which the water vapour in the air will condense into liquid water (otherwise known as the Dew Point). If you have a dew point of, say 24 degrees Celsius, this means that if the water vapour in the air stays above that temperature, it will remain as water vapour but as soon as it drops below that temperature (for example, when it comes into contact with a window) the water vapour will become liquid water (i.e., condensation). Therefore a high dew point is not good.

The two things that affect the dew point are temperature and relative humidity.

4

Recovering latent heat

With evaporation latent heat is 'taken in' when the water changes phase from liquid to vapour.

With condensation it's the exact opposite - latent heat is 'given out' when the water changes phase from vapour to liquid.

Air handlling units are able take this heat and transfer some of it to the incoming air supply.

5

Poolside

The comfort of bathers (before entering and after leaving the pool) and of the poolside staff are the key elements to be addressed at the poolside. Most of the people who use the pool hall will be wet, so the poolside temperature should be adjusted accordingly. This can be assisted, for example, by redirecting any grilles and jets near the poolside to avoid any direct air flow from the ventilation system.

Staff should also be discouraged from opening doors or windows, which creates draughts. Discourage poolside staff from opening emergency escape doors for their own personal comfort. If localised cooling is required, this can be provided by increased air movement such as through simple overhead fans. Use controls to avoid increasing air movement at the pool surface or around wet bathers.

6

Protecting the structure

The key elements to be addressed in other areas of the pool hall are protecting the pool hall structure from condensation and providing comfort to non-swimmers.

One solution to both problems is to provide separate air flows for the pool and other areas to minimise mixing between areas. In a new pool building, the airflow could be directed upwards from a slot at the foot of the walls in 'laminar flow', so that it mixes as little as possible with the bulk of air in the hall. For existing pool buildings, inlet grilles and jets can be repositioned so that drier air entering the pool hall can be pointed towards the sides of the building rather than down on to the pool.

Comfort for spectators can be improved by having a similar arrangement to direct drier incoming air over them. It may also be appropriate to blow drier air into ceiling voids to ensure that condensation does not occur on hidden parts of the structure.

Other ways of energy saving

Reduce flow rate

When the pool is out of use, the requirement to achieve the turnover time can be relaxed. This can enable operators to turn one or more (but not all) of the

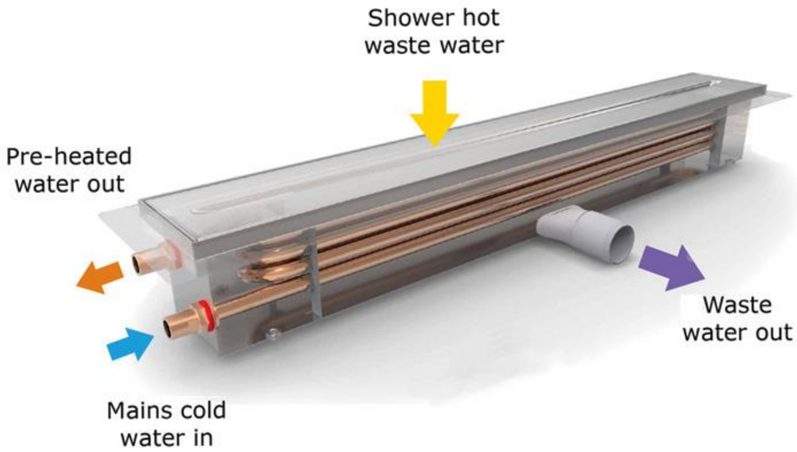
circulation pumps off overnight and make considerable cost savings.

This also has the added benefit of slowing down the filtration rate. Filtration works best the slower it is, so you could end up will twice as good filtration efficiency for a fraction of the cost.

Supply showers and toilets with pool water

Typically, pre swim showers and wet-side changing room toilets are supplied with water from the mains. As an alternative, at may be possible to plumb the supply from the swimming pool water instead of the mains. That way, whenever someone flushes the toilet or takes a pre-swim shower (which should be everybody), the water supply is from the swimming pool, where the water is already warm (good for showering) and disinfected with chlorine (also good for showering, but also good for disinfecting bathers prior to their getting in the pool.

Waste water heat recovery



Think of all the warm water that a typical swimming pool expels from the showers and when backwashing the filtration system. In most cases, this water is simply wasted, missing the opportunity to recover some of the heat in the water.

There are numerous types of systems that can effectively recover the heat and transfer to the incoming water supply thus reducing the demand on the main heating system and saving money as a result.

Knowledge Test (check answers with tutor)

In a swimming pool, heating the water is the single biggest energy cost.

- True
- False

Air movement at the pool surface encourages what to occur.

- Increases the relative humidity
- Evaporation
- Condensation

Fill in the blanks below from the following list:

- outgoing
- Vapour
- condensing coil
- latent heat

Air handling units capitalise on ________ stored in the air by passing ________ air (which is warm and moist) through a ________. As the air passes through, the water that is contained within the air in the form of ________ condenses onto the coil. This process gives out latent heat energy and this heat can be redirected (to the evaporating coil on the incoming air supply for example).

What is relative humidity?

- How hot someone feels relative to the outside air temperature.

○ The amount of water vapour contained in the air expressed as a percentage of the maximum amount of vapour the air could contain at that temperature.

○ How hot and stuffy the atmosphere feels.

11. The Management of Swimming Pools

On completion of this lesson, you'll know your legal responsibilities in relation to the operation of commercial swimming pools and be able to develop and implement processes and procedures to meet these responsibilities.

Legal Responsibilities

Both employers and employees have duties under UK Health & Safety Legislation to provide a safe environment and protect those who use public swimming pools. The primary legislation is the Health and Safety at Work Act and this is reinforced by the Management of Health and Safety at Work Regulations.

The Health and Safety at Work etc. Act 1974 (HSWA), the Management of Health and Safety at Work Regulations 1999 (MHSWR) and the Control of Substances Hazardous to Health Regulations 2002 (COSHH) impose certain statutory duties on all managers of non-domestic swimming pools. Duties under the HSWA extend to risks from infectious agents arising from work activities, i.e. risks to non-employees. The MHSWR provide a broad framework for controlling health and safety at work. COSHH provides a framework aimed at controlling the risks from hazardous substances including infectious agents.

The Health & Safety Law Poster

You might already be familiar with this poster as it's displayed in most UK workplaces. See the numbered list that follows for more information about how it might apply to Pool Plant Operators (from the 'What you must do' section of the poster.

Examples of legal duties of Pool Plant Operators

1. **From The Management of Health and Safety at Work Regulations 1999**
   Pool Operators must abide by the training they have received during internal training sessions (on handling chemicals safely for example) and any accredited external training leading to qualifications such as the Pool Plant Operator Qualification.
2. **From the Health and Safety at Work etc. Act 1974.**
   As a Pool Plant Operator, the safety of people using the swimming pool is dependant on the actions you take, or don't take. For example, if you do not ensure that the swimming pool water is adequately disinfected by carrying out regular pool water tests, and someone gets an infection because of that, it might be argued that you did not take reasonable care
3. **From the Health and Safety at Work etc. Act 1974.**
   A Pool Plant Operator could be found to be in breach of this duty by, for example, failing to follow written procedures set out in the Normal Operating Procedures (NOP) or Emergency Action Plan (EAP).
4. **From The Management of Health and Safety at Work Regulations 1999**
   This could involve reporting any issues with the pool water treatment system (eg. insufficient chlorine or other problems identified through pool tests).

The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR)

These Regulations require employers and others to report accidents and some diseases arising out of or in connection with work to the Health and Safety Executive. For example, certain case(s) of Legionnaires' disease are reportable under RIDDOR. Further information on RIDDOR can be found in HSE guidance or on the HSE website at http://www.riddor.gov.uk

Confined Spaces Regulations 1997

These Regulations were made under the Health and Safety at Work etc Act (HSW Act) 1974 and came into force on 28 January 1998. The Regulations apply in all premises and work situations in Great Britain subject to the HSW Act, with the exception of diving operations and below ground in a mine (there is specific legislation dealing with confined spaces in these cases). These Regulations also extend outside Great Britain in a very limited number of cases.

A confined space is a place which is substantially enclosed (though not always entirely), and where serious injury can occur from hazardous substances or conditions within the space or nearby (e.g. lack of oxygen).

Under domestic law (the Health and Safety at Work etc Act 1974) employers are responsible for ensuring the safety of their employees and others. This responsibility is reinforced by regulations.

The Confined Spaces Regulations 1997 Apply where the assessment identifies risks of serious injury from work in confined spaces.

These regulations contain the following key duties:

- avoid entry to confined spaces, e.g. by doing the work from the outside;
- if entry to a confined space is unavoidable, follow a safe system of work; and
- put in place adequate emergency arrangements before the work starts

The Construction, Design and Management (CDM) Regulations 2015

The CDM Regulations require that health and safety is taken into account and managed throughout all stages of a project, from conception, design and planning through to site work and subsequent maintenance and repair of the structure. These regulations apply to most common building, civil engineering and engineering construction work (including demolition, dismantling and refurbishment). Clients and designers have specific duties under the regulations. Further information on health and safety during construction can be obtained from the HSE website (http://www.hse.gov.uk/construction/) where there is information on these regulations and references to relevant leaflets and guidance.

Risk Assessment

What is 'Risk Assessment'

To conduct a risk assessment, you need to think about what might cause harm to people and decide whether reasonable steps are being taken to prevent or control it.

This is known as risk assessment, which is required by law. A risk assessment is not about creating massive amounts of paperwork but identifying sensible measures to control the risks.

Risk is a combination of consequences and the likelihood of those consequences occurring. When establishing the likelihood of harm, the adequacy of existing control measures should be considered.

The legal framework for risk management

The key legal requirements for the assessment and management of risk are contained in Regulations 3, 4 and 5 of the Management of Health and Safety at Work Regulations 1999.

Regulation 3 - Risk assessment

The employer is required to make a suitable and sufficient assessment of:

- The health and safety risks to which employees are exposed whilst at work
- The health and safety risks to which people other than employees (i.e. visitors, contractors, members of the public etc.) are exposed arising out of or in connection with the conduct of the business

Regulation 4 - Principles of prevention

Any risk control measures required as a result of the risk assessment should be in accordance with the principles of prevention.

Regulation 5 - Health and safety arrangements

Every employer is required to give effect to appropriate arrangements for the effective planning, organisation, control, monitoring and review of the risk control measures, as appropriate for the nature of the activities and the size of the business.

Suitable and sufficient

'Suitable and sufficient' is not defined in the Management of Health and Safety at Work Regulations. The Approved Code of Practice for the Regulations suggests that a suitable and sufficient risk assessment should do the following:

a) identify the risks arising from or in connection with work
b) be proportionate to the risk
c) consider all those who might be affected whether they are workers or others such as members of the public
d) demonstrate that reasonable steps have been taken to identify hazards, e.g. by researching relevant legislation, guidance, supplier manuals, manufacturers' instructions or advice from competent sources
e) use relevant examples of good practice from within their industry
f) be appropriate to the nature of the work and should identify the period of time for which it is likely to remain valid

The Approved Code of Practice (ACoP) further recommends that a risk assessment should:

a) Ensure the significant risks and hazards are addressed
b) Ensure all aspects of the work activity are reviewed, including routine and non-routine activities
c) Cover all parts of the work activity, including those that are not under the immediate supervision of the employer, e.g. employees working off site as contractors
d) Take account of the non-routine operations, e.g. maintenance or cleaning

e) Be systematic in identifying hazards and looking at risks e.g. by:
   - Grouping hazards
   - Dividing site geographically
   - Operation by operation
f) Take account of the way in which work is organised, and the effects this can have on health
g) Take account of risks to the public.

Who should risk assess?

The legal responsibilities to ensure that risk assessments are made rests upon the employer who is required to appoint one or more competent persons, to assist him in undertaking the measures he needs to take to comply with the requirements and prohibitions imposed upon him by health and safety legislation, including the completion of 'suitable and sufficient' risk assessments.

Competence is not achieved by obtaining a particular qualification, but results from a combination of adequate knowledge and skills, experience and certain personal qualities such as good judgement.

To be competent for straightforward risk assessments, risk assessors require:

a) Experience and training in hazard identification and carrying out risk assessments
b) Knowledge of the processes or activities to be assessed
c) Technical knowledge of the plant or equipment
d) Good communication and report writing skills
e) Ability to interpret legislation and guidance
f) The right attitude for the task
g) An understanding of current best practice in the area of work
h) An awareness of the limitations of one's own experience and knowledge
i) The willingness and ability to supplement existing experience and knowledge, when necessary by obtaining external help and advice

Risk assessments should be practical and well rounded. They should take account of the views of employees, safety representatives, managers and technical experts as necessary.

More complicated assessments may require more specific applied knowledge and skills which can only be delivered by appropriately qualified specialists.

Enforcement

Enforcement of health and safety legislation falls to two bodies, the Health and Safety Executive and Local Authorities (LAs). The HSE are responsible for enforcement with respect to designers, manufacturers and installers and for pools in premises where HSE is the enforcing authority eg. government buildings, factories. LAs are responsible for enforcement in hotels, retail outlets, and private sports and fitness clubs.

The majority of commercial pools will be under the enforcement of Local Authorities. Both HSE and LA inspectors will expect employers to meet their legal responsibilities as explained in the COSHH ACoP and L8. Each LA will make their own arrangements for inspections and water quality monitoring.

The enforcing authorities have the power to close a pool (Prohibition Notice) if there is an imminent risk to health. They can also require improvements (Improvement Notice) where the management of a pool is falling below legal standards.

The 5 steps of risk assessment

The HSE advises a basic five steps to risk assessment approach.

Step 1: Identify the hazards

A hazard is anything with the potential to cause harm. Some relevant hazards for pool plant operators to consider would be, for example:

- pool water treatment chemicals
- biological agents
- confined spaces
- manual handling

Hazards may also be categorised as:

- **Mechanical** example: moving parts of machinery or moving vehicles.
- **Physical** example: noise or vibration energy, radiation, or electricity.
- **Biological** example: legionella bacteria or blood borne viruses.
- **Chemical** example: corrosive or toxic cleaning chemicals.
- **Ergonomic** example: poor posture or repetitive work at a computer workstation.
- **Psychosocial** example: pressure of work or shift work.

The approaches to hazard identification will vary from workplace to workplace depending on the complexity of the business and the hazards present. Whatever the context it is important that a consistent approach is determined to ensure that significant hazards are proactively identified.

The following tools and approaches can be useful in most workplaces:

a) Workplace Inspections: Look around to identify any obvious concerns.
b) Workforce Involvement: Ask the employees, or their representatives for their opinion. The people directly involved in tasks and processes will be very aware of any serious concerns.
c) Information and Advice:

- The HSE website has readily available advice on common hazards and practical controls
- Workplace Health Connect provides a free workplace health and safety advisory service for small and medium-sized enterprises
- Trade associations often produce helpful guidance
- Manufacturer's instructions / data sheets can be very helpful in identifying specific hazards and controls

d) Historical Records: Accident and ill-health records can often help to identify the less obvious hazards, including hazards to health (e.g. from exposure to high levels of noise or harmful fumes).

Step 2: Decide who might be harmed and how

Think how colleagues (or others who may be present, such as contractors or visitors) might be harmed. Ask the people who do the activity you're risk assessing what they think the hazards are, as they may notice things that are not obvious to you and may have some good ideas on controlling the risks.

For each hazard, you need to be clear about who might be harmed – it will help you identify the best way of controlling the risk. That doesn't mean listing everyone by name, but instead identifying groups of people (e.g. people working in the storeroom or passers-by). Remember:

- Some workers may have particular requirements, e.g. new and young workers, migrant workers, new or expectant mothers, people with disabilities, temporary workers, contractors, homeworkers and lone workers.
- Think about people who might not always be in the workplace, such as visitors, contractors and maintenance workers.
- Take members of the public into account if they could be harmed by your work activities.
- If you share a workplace with another business, consider how your work affects others and how their work affects you and your workers. Talk to each other and make sure controls are in place.
- Ask colleagues if there is anyone you may have missed.

Step 3: Evaluate the risks and decide on precautions

Risk is a combination of consequences and the likelihood of those consequences occurring. When seeking to establish the likelihood of harm, the adequacy of existing control measures should be considered.

Likelihood					
Very High (no controls in place)	5	10	15	20	25
High (very few controls in place)	4	8	12	16	20
Medium (some controls in place)	3	6	9	12	15
Low (most controls in place)	2	4	6	8	10
Very Low (all controls in place)	1	2	3	4	5
Consequence	Slight (no lost time)	Minor (< 7 days absence)	Medium (> 7 days absence)	Major (long term disablement)	Fatal

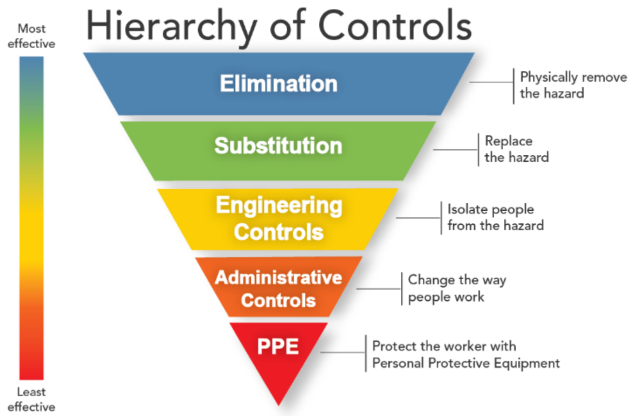
High Risk	Stop activity and implement controls.
Tolerable Risk	Keep under close review. Implement further controls within specified timescale.
Low Risk	Maintain current level of control.

How to reduce risk by applying the 'hierarchy of risk control'

Having completed a risk assessment and having taken account of existing controls, the next step is to determine whether existing controls are adequate or need improving, or if new controls are required.

If new or improved controls are required, their selection should be determined by the principle of the hierarchy of controls, i.e. the elimination of hazards where practicable, followed in turn by substitution, with the adoption of personal protective equipment (PPE) as a last resort.

The following provides examples of implementing the hierarchy of controls:



1. **Elimination** - Redesign the job or substitute a substance so that the hazard is removed or eliminated.
2. **Substitution** - Replace the material or process with a less hazardous one.
3. **Engineering controls** - for example use work equipment or other measures to prevent falls where you cannot avoid working at height, install or use additional machinery to control risks from dust or fume or separate the hazard from operators by methods such as enclosing or guarding dangerous items of machinery/equipment. Give priority to measures which protect collectively over individual measures.
4. **Administrative controls** - These are all about identifying and implementing the procedures you need to work safely. For example: reducing the time workers are exposed to hazards (eg by job rotation); prohibiting use of mobile phones in hazardous areas; increasing safety signage, and performing risk assessments.
5. **Personal protective clothes and equipment** - Only after all the previous measures have been tried and found ineffective in controlling risks to a reasonably practicable level, must personal protective equipment (PPE) be used. For example, where you cannot eliminate the risk of a fall, use work equipment or other measures to minimise the distance and consequences of a fall (should one occur). If chosen, PPE should be selected and fitted by the person who uses it. Workers must be trained in the function and limitation of each item of PPE.

In applying the hierarchy consideration should be given to the relative costs, risk reduction benefits, and reliability of the available options.

Consider:

1. the need for a combination of controls, combining elements from the above hierarchy (e.g. engineering and administrative controls),
2. established good practice in the control of the particular hazard under consideration,
3. adapting work to the individual (e.g. to take account of individual mental and physical capabilities),
4. taking advantage of technical progress to improve controls,
5. using measures that protect everyone [e.g. by selecting engineering controls that protect everyone near a hazard in preference to personal protective equipment (PPE)],
6. human behaviour and whether a control measure will be accepted and can be effectively implemented,
7. typical basic types of human failure (e.g. simple failure of a frequently repeated action, lapses of memory or attention, lack of understanding or error of judgement, and breach of rules or procedures) and ways of preventing them,

8. the need to introduce planned maintenance of, for example, machinery safeguards,
9. the possible need for emergency/contingency arrangements where risk controls fail,
10. the potential lack of familiarity with the workplace and existing controls of those not in the direct employment of the organization, e.g. visitors, contractor personnel.

Step 4: Record the findings and implement them

Putting the results of the risk assessment into practice will make a difference in improving the health and safety of employees and others affected by the work. The results of the risk assessment should be documented and shared with staff. If there are fewer than five employees legally the risk assessment does not need to be documented. The record is useful however in:

a) demonstrating the process undertaken
b) in sharing information with employees
c) in facilitating review processes when things change

Legally the risk assessment must be suitable and sufficient. This means that it should show that:

a) a proper check has been made
b) all those who might be affected have been considered
c) all the significant hazards have been addressed, considering the number of people who could be involved
d) the precautions are reasonable, and the remaining risk is low
e) staff or their representatives were involved in the process

If after completing the risk assessment there are a lot of improvements that need to be made an action plan should be developed to prioritise them so that they can be dealt with on a ‘worst first’ basis

A good action plan might include:

a) a few ‘quick wins’ - cheap or easy improvements that can be done quickly, perhaps as temporary solutions until more reliable controls are in place
b) long-term solutions to those risks with the worst potential consequences, especially personal injury or ill-health
c) arrangements for training employees on the main risks that remain and the corresponding controls
d) arrangements for monitoring to ensure that the control measures stay in place
e) clear responsibilities for leading on individual actions
f) target dates for completion

Step 5: Review the risk assessment and update if necessary

Few workplaces stay the same. Sooner or later, equipment, substances and procedures are updated, often with the introduction of new hazards. Risk assessments should therefore, be reviewed on an on-going basis. If a significant change occurs, ideally the risk assessment should be reviewed as part of the change management process, and revised if necessary.

In addition, a formal review should be undertaken every year or so to ensure progress against the action plan and to show that standards are being maintained or are continually improving.

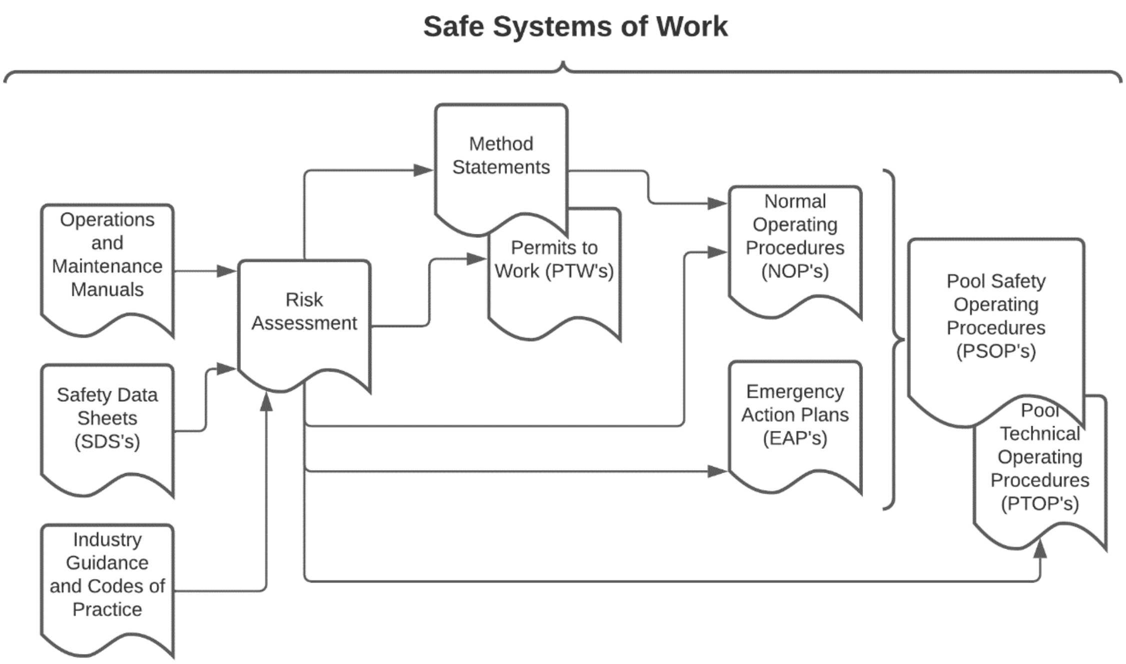
The review should consider:

a) Any changes to equipment, substances or procedures
b) Any problems reported by the workforce
c) Any lessons learnt from accidents or near misses

Operating Procedures

The swimming pool and associated plant and facilities (such as the changing rooms, showers, pumps, filters etc.) should be operated and managed according to a robust set of procedures that have been devised following a comprehensive and rigorous assessment of the hazards and risks that are present.

The diagram lays out how all the various processes involved with commercial swimming pool operations work together to provide a suite of effective operating procedures.



Training

In a commercial swimming pool, it is important that there are enough competent people involved with the day-to-day operation and management of it. There should always be a supervisor (or equivalent) on-site, who has attended a course of training such as a Pool Plant Operator course and met the associated assessment criteria. In order to fulfil this requirement, there would need to be a team of people who hold this type of qualification in order to account for annual leave and sickness etc.

Further to this requirement, all people involved with the testing of swimming pool water and the cleaning and supervision of a swimming pool facility should have attended a course of training such as a 1-day Pool Plant Foundation course and met the associated assessment criteria.

If there are not enough trained and competent staff available to assist with the running of a commercial swimming pool, errors and omissions are a likely outcome.

Operation and Maintenance Manuals

An O&M manual is provided to the management of a building by the organisation that designed or built it and contain details such as manufacturers' instructions and health and safety guidance, and as-built drawings and schematics of the building.

The O&M Manual should be used to help inform risk assessments, which in turn inform risk control systems, and the Pool Safety Operating Procedures (PSOP).

If the O&M Manuals contain schematic drawings of the pool and associated plant, these should be referred to when any work is carried out on the system (eg. addition of chemical dosing units, UV disinfection systems etc.).

Safety data sheets (SDS)

A SDS will contain the information necessary to allow employers to do a risk assessment as required by the Control of Substances Hazardous to Health Regulations (COSHH). The SDS itself is not an assessment. However, it will describe the hazards helping employers assess the probability of those hazards arising in the workplace.

Industry Guidance and Codes of Practice

The main source of industry guidance for swimming pools in the UK is the Pool Water Treatment Advisory Group (PWTAG). They produce a Code of Practice that provides a framework for swimming pools to develop their operating procedures around.

Risk Assessment

Risk assessment is the central hub in this diagram. The Safety Data Sheets, O&M Manuals, Codes of Practice etc. are INPUTS into the risk assessment process. The Method Statements, Permits to Work, Operating Procedures etc. are OUTPUTS from the risk assessment process.

Method Statements

These are step-by-step, documented procedures that explain how to perform tasks safely. It's a set of instructions for doing a task right, first time, every time. They are intended to be used by those people actually carrying out the work, therefore, they should be as user-friendly as possible and not crammed with useless information or technical jargon. Otherwise, they're likely to just be ignored. They may come in different formats, such as step-by-step instructions, checklists, decision aids, diagrams, flow-charts and etc.

In the UK swimming pool sector, many of these method statements will be included in the Pool Safety Operating Procedures.

Some organisations don't use the term 'method statement' and might instead refer to them as 'work instructions'. Here's how the Health and Safety Executive (HSE) define method statements…

"Method statements describe in a logical sequence exactly how a job is to be carried out in a safe manner and without risks to health. It includes all the risks identified in the risk assessment and the measures needed to control those risks. This allows the job to be properly planned and resourced."

Permits to Work (PTW)

Method statements (or, work instructions) are adequate for most work activities, but some work requires extra care. A 'permit to work' is a more formal system stating exactly what work is to be done and when, and which parts are particularly hazardous. A responsible person should assess the work and check safety at each stage. The people doing the job sign the permit to show that they understand the risks and precautions necessary.

Permits are effectively a means of communication between site management, plant supervisors and operators, and those who carry out the work. Examples of high-risk jobs where a written 'permit to work' procedure may need to be used include

- hot work such as welding,
- vessel entry,
- cutting into pipework carrying hazardous substances, and
- work that requires electrical or mechanical isolation.

It is also a means of coordinating different work activities to avoid conflicts.

The terms ‘permit-to-work’, ‘permit’ or ‘work permit’ refer to the paper or electronic certificate or form which is used as part of an overall system of work, and which has been devised by a company to meet its specific needs.

Normal Operating Procedures (NOP’s)

These set out how the pool should operate under normal day-to-day conditions. Some examples of procedures for inclusion would be:

- pool dimensions;
- features and equipment (such as flumes etc.);
- rescue equipment;
- location of pool alarms;
- floor plans;
- potential hazards;
- access and restrictions;
- bathing loads;
- diving policy;
- vulnerable swimmers;
- lifeguarding;
- pool rules;
- cleaning procedures;
- hiring procedures;
- accident reporting.

Emergency Action Plans (EAP’s)

These set out the actions to be taken for the range of reasonably foreseeable emergency scenarios…

- fire;
- gas escape;
- chemical spill;
- structural failure;
- bomb threat;
- power failure;
- pool rescue;
- evacuation of disabled users;
- overcrowding;
- contamination of pool water;
- disorderly behaviour;
- sexual assault;
- flooding.

Pool Safety Operating Procedures (PSOP's)

NOP's and EAP's are often referred to collectively as the Pool Safety Operating Procedures (PSOP's).

Plant Room Visit

What type is the water surface draw-off system?	
How many sump outlets are there?	
Can you identify any issues regarding the outlets that may create entrapment/entanglement hazards?	
How many circulation pumps are there? If there is more than one circulation pump, how many are on duty and how many are on standby?	
Is there a flow-rate meter? If yes, what is the flow-rate reading?	
Is there a coagulant being dosed into the circulation system? If yes, what is the chemical name?	
How many filters are there?	
Are there inlet and outlet pressure gauges fitted to the filters? If yes, what are the readings?	
What is the name of the chemical being used as the disinfectant? Is it being dosed pre or post filter?	
What is the name of the chemical being used as a pH correctant?	
Is the chemical dosing automatically controlled? If yes, what are the control panel readings?	
Is the heat exchanger visible?	
Are all the chemicals being stored safely? If not, what issues have you identified?	

Pool Test Log Sheet

Swimming Pool Log Sheet - Monday / / to Sunday / /																												
	Mon				Tue				Wed				Thu				Fri				Sat				Sun			
Pumps in use	1 2 3 4 5				1 2 3 4 5				1 2 3 4 5				1 2 3 4 5				1 2 3 4 5				1 2 3 4 5				1 2 3 4 5			
Strainers cleaned	Y / N				Y / N				Y / N				Y / N				Y / N				Y / N				Y / N			
Filters pressures (Bar)	In		Out		In		Out		In		Out		In		Out		In		Out		In		Out		In		Out	
Chlorine added (scoops)																												
Chlorine in stock (tubs)																												
Dry acid added (scoops)																												
Dry acid in stock (bags)																												
Test results	Fr	Tl	Co	pH	Fr	Tl	Co	pH	Fr	Tl	Co	pH	Fr	Tl	Co	pH	Fr	Tl	Co	pH	Fr	Tl	Co	pH	Fr	Tl	Co	pH
1 Before public admission																												
2 9.00am.																												
3 11.00am.																												
4 1.00pm.																												
5 3.00pm																												
6 5.00pm.																												
7 7.00pm																												
8 9.00pm.																												
9 Close																												
Water temp.																												
Air temp.																												
Clarity. 10 = perfect 0 = poor																												
Control panel readings	pH		Cl		pH		Cl		pH		Cl		pH		Cl		pH		Cl		pH		Cl		pH		Cl	
Before public admission																												
Close.																												
Backwash (mins)																												
Source water:	Fr	Tl	Co	pH																								
Total alkalinity/factor																												
Calcium hardness/factor																												
Temperature factor																												
Total dissolved solids (pool)																												
Total dissolved solids (source)																												
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Candidate Assessment Portfolio

Candidate Name:	
Course Venue:	
Course Date(s):	

Please complete the following exercises and return the full portfolio (including this page) to:

Stockwell Safety
Duddon House
Lach Dennis
Northwich
Cheshire
CW9 7TB

We strongly advise keeping a copy of the portfolio for your records.

All work **MUST BE YOUR OWN**.

Water Testing and Backwash Evidence Submission

It is a ***management responsibility and legal duty*** to ensure staff are competent. Therefore, it is important that management are involved in the training and development of staff.

The candidate must carry out the following tasks in accordance with the sites normal operating procedures. The candidate must then sign below, along with the counter signatories, who must sign only once they are satisfied that the tasks have been carried out to the required standards.

Task	Date(s) Completed (some tasks may involve several supervised sessions before full competence is demonstrated)
Backwash of the filtration system, including cleaning the strainer basket(s).	
Pool Water Tests: Free chlorine, Total chlorine, Combined chlorine, pH	
Calcium hardness, Total alkalinity, Total dissolved solids, Temperature	

Candidate Declaration: I am confident that I know how to carry out the tasks above and have competently performed them at my workplace in accordance with our Normal Operating Procedures.

Candidate Name	Candidate Signature

Counter signatory Declarations: We are confident that the candidate is competent to carry out the tasks above in accordance with our Normal Operating Procedures.

Counter signatory 1 Job Title [1]	Counter signatory 1 Name	Counter signatory 1 Signature
Counter signatory 2 Job Title [2]	**Counter signatory 2 Name**	**Counter signatory 2 Signature**

[1] This must be a qualified and experienced Pool Plant Operator with supervisory responsibilities (evidence of qualification must be sent to us, e.g. copy of certificate)
[2] This must be the most senior manager at your site (i.e., Centre Manager, General Manager etc.)

An Alternative Assessment Method Where Evidence Submission is not Possible

The 'Evidence Submission' method of assessment should be straight-forward for sites that have a robust management structure and a skills continuity policy in place, and this should be the objective for all sites operating commercial wet-side facilities.

If it is deemed to be not possible for any reason, this should serve as a prompt to management to make the required improvements. In the meantime, the alternate assessment method outlined below may be used.

Submission of a video file of the candidate performing the tasks detailed in the above section, explaining what they're doing as they go.

- Photo-ID should be shown at the beginning of the video to prove authenticity (passport or driving license or photo ID card)
- The whole session (of each task/test) should be filmed non-stop from start to finish
- The learner should remain in camera shot at all times
- The video should not be edited in any way
- The learners' voice must be able to be heard
- The video needs to be of good quality to ensure skills are visible

This option might be also be suitable for people who are not working within a formal management structure.

Contact us directly if you require technical assistance with any aspect of video creation and submission.

Schematic Diagram

A schematic diagram of the layout of a swimming pool plant must be sketched out by the candidate on the following page. This should indicate clearly (using arrows to indicate the direction of flow) each of the main components, including:

- Pool tank
- Balance tank (if present)
- Surface water draw-off
- Sumps
- Strainers
- Pumps
- Filters
- Heating
- Chemical tanks and pumps (if none - indicate that on the schematic)
- Monitoring equipment (if none - indicate that on the schematic)
- Main valves

You must draw the schematic by going around the system and familiarising yourself with the layout. Don't just copy a schematic from a book etc. as you will learn nothing by doing so.

Also, the work needs to be your own - even if a fellow course candidate is drawing the same system. Don't just copy their work - draw your own schematic. It will be similar, but not identical.

COSHH Assessment

Complete the COSHH assessment by filling in the boxes below. Every box must be completed. The signature required at the end is your signature, even if you are not the 'official' COSHH Assessor for your site.

Note. This is an academic exercise. This document should not be used in place of a 'real' COSHH assessment.

Name of chemical?	**Trade name** (if applicable).
What is the chemical used for?	
What is the physical form of the substance, (i.e. solid, gas, liquid)?	**What are the main routes of entry (i.e. inhalation, skin contact, ingestion)?**
What hazard classifications does the chemical have (i.e. corrosive, irritant, toxic etc.)?	
Who might be harmed by this substance?	
How could exposure to the substance occur? Think about tasks involving the substance and how exposure to the substance could occur under both normal AND emergency situations.	
What control measures are currently in place to minimise the risk?	

What is the severity of harm that could be caused by exposure to the substance? Use the risk rating system in the Health and Safety chapter of the PPO manual.	**What is the likelihood that harm will be caused?** Again, use the risk rating matrix.	**What is the overall risk rating?** Multiply the previous two numbers together.
Severity	**Likelihood**	**Risk Rating**

What further control measures could reduce the risk? Remember to prioritise the control measures; PPE is the LAST report.	**How could new control measures be implemented?**
Name and signature of COSHH assessor	**Date of COSHH assessment**

Course Feedback

1. Would you recommend this course to others?

Yes ☐ No ☐

2. What's the best way we could improve the delivery, the booking procedure or anything about the course? Be as specific as you like...

3. Are there any other comments you would like to add? Please write below…

4. Your Name, Job Title and Company (only put this if you're OK with us using the information for testimonials on our website etc.)

Name	Job Title	Company

Complaints Policy

If you are not satisfied with any aspect of our service, we have a formal complaint policy, which can be accessed via our website:

https://stockwellsafety.com/policies

STOCKWELL SAFETY

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