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01. Introduction to Swimming Pools

History of Swimming Pools in the UK

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 here 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.

Nowadays, there is a wide variety of different types and uses of swimming pools:

- Above-ground pools
- Birthing pools
- Competition pools
- Diving pools
- Hydrotherapy pools
- Leisure pools
- Outdoor pools
- Spa pools
- 'Traditional' Pools
- Teaching pools

The above list is only a small representative set of examples.

Swimming Pool Construction

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 ceramic one-piece shell
- An above-ground pool

02. The Management of Swimming Pools

Management Responsibility

The Health and Safety at Work etc. Act 1974 (HSWA), the Management of Health and Safety at Work Regulations1999 (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.

Duties under Section 3 of the HSWA

If people working under the control and direction of others are treated as self-employed for tax and national insurance purposes, they are nevertheless treated as employees for health and safety purposes. It may, therefore, be necessary to take appropriate action to protect them. If any doubt exists about who is responsible for the health and safety of a worker, this could be clarified and included in the terms of a contract. However, a legal duty under Section 3 of HSWA cannot be passed on by means of a contract and there will still be duties towards others under Section 3 of HSWA. If such workers are employed on the basis that they are responsible for their own health and safety, legal advice should be sought before doing so.

Management of Health and Safety at Work Regulations 1999

Under these Regulations the manager of a pool is required to

- assess the risks in their workplace
- use competent help to apply health and safety legislation
- establish procedures to use if an employee is presented with serious and imminent danger
- co-operate and co-ordinate health and safety if there is more than one employer in a workplace

Approved Codes of Practice

Approved Codes of Practice (ACoP) offer practical examples of good practice and how to comply with the law. If, for example, regulations use words like ‘suitable and sufficient’ or ‘reasonably practicable’, an ACoP can illustrate what this requires in particular circumstances.

Approved Codes of Practice have a special legal status which can be expressed positively or negatively.

The Approved Code of Practice for the Management of Health and Safety at Work Regulations 1999 (L21) (now withdrawn) states:

If you follow the advice you will be doing enough to comply with the law in respect of those specific matters on which the Code gives advice. You may use alternative methods to those set out in the Code in order to comply with the law.

The ACoP for the Workplace (Health, Safety and Welfare) Regulations 1992 (L24) states:

This Code has been approved by the Health and Safety Commission and gives advice on how to comply with the law. This Code has a special legal status. If you are prosecuted for breach of health and safety law, and it is proved that you have not followed the relevant provisions of the Code, a court will find you at fault, unless you can show that you have complied with the law in some other way.

However, a failure on the part of any person to observe the provisions contained in an ACoP does not, of itself, render that person liable to any criminal or civil proceedings.

In criminal proceedings the provisions of a relevant ACoP are admissible in evidence, and a failure to observe them constitutes proof of the breach of duty or contravention of the legal duty in question, unless the accused satisfies the court that he complied with the requirement of the law in some other equally effective manner.

In civil proceedings it is likely that a failure to observe the provisions of an ACoP could constitute prima facie evidence of negligence, which would have to be rebutted by evidence to the contrary.

Guidance Notes

Guidance notes may be specific to the health and safety problems of an industry or of a particular process used in a number of industries.

The main purposes of guidance notes are to:

- help people to understand what the law says including, for example, how requirements based on EC Directives fit with those under the Health and Safety at Work Act
- help people comply with the law
- give technical advice

The HSE may issue a guidance note together with an Approved Code of Practice (ACoP), or independently. Guidance notes contain practical advice and sound suggestions, and are frequently more informative than the related ACoP. The HSE aims to keep guidance up to date, because as technologies advance, workplace risks and appropriate control measures change too.

Following guidance is not compulsory and employers are free to take other action but if they do follow guidance they will normally be doing enough to comply with the law.

Although guidance notes have no legal standing they can be used as evidence of the state of knowledge at the time of issue.

An example of guidance, published by the HSE and relevant to the management of swimming pools is 'HSG179 Managing Health and Safety in Swimming Pools'. This document can be downloaded, free of charge from the HSE website.

A further example of guidance, published by the Pool Water Advisory Group (PWTAG) is 'Swimming Pool Water: Treatment and Quality Standards for Pools and Spas, which has more detailed information regarding pool water treatment than the HSG170 guidance.

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.

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 Reporting of Injuries, Disease sand 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

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.

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 3-day 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.

Pool Safety 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. These procedure are referred to as the Pool Safety Operating Procedures (PSOP) and are comprised of two sections, the Normal Operating Procedures (NOP) and the Emergency Action Plans (EAP). These are discussed in more detail below.

Normal Operating Procedures

These procedures set out how the pool should operate under normal day-to-day conditions. The following types of information should be included:

- Pool dimensions
- Features and equipment (such as flumes etc.)
- Rescue equipment
- Location of pool alarms
- Floor plan of pool and pool hall
- Potential hazards
- Access and restrictions
- Bathing loads
- Diving policy
- Vulnerable swimmers
- Lifeguarding procedures
- Pool rules
- Cleaning procedures
- Hiring procedures
- Accident reporting

Emergency Action Plans

These set out the actions to be taken for the range of reasonably foreseeable emergency scenarios. Examples of those that should be included are included here and some are discussed in more detail below:

- 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

Fires and Explosions

The risk of fire and explosion in pool plant rooms is particularly high due to the chemical properties of the chemicals involved. A thorough and robust fire and explosion risk assessment must be carried out. Good prevention management strategies, including training of staff, correct storage of chemicals etc. will go a long way to reducing the risk. Emergency situations should be thought about in advance, and procedure for dealing with them should be practiced regularly. The fire service will need to be made aware of the chemicals that are stored on the premises, so it would be a good idea to prepare a file in advance to hand over to the fire service in the event of an emergency.

Chemical Incidents

The main ways chemicals can harm the body are via:

- Contact with skin, eyes etc.
- Ingestion
- Inhalation

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.

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.

For ingestion of chemicals, the casualty should sip water or milk to help dilute the chemicals. Vomiting should not be encouraged. If the casualty becomes unconscious, they should be placed into the recovery position and monitored, if they stop breathing, then artificial respiration should commence.

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.

In the above scenarios, kit'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 Material Safety Data Sheet (MSDS) must accompany the casualty to the hospital.

For spillages of chemicals, the Pool Water Treatment Advisory Group (PWTAG) provide the following procedure:

In any emergency a quick but calm reaction is necessary. Personnel and the public must be protected. 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.

Whatever the cause, the approach to any spill is to:

- follow the emergency action plan
- protect the public
- protect staff
- contain the spill
- stop the leak
- clean up the spill
- protect the environment

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.

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.

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.

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.

Chemical or Microbiological Contamination Outbreaks

A chemical or microbiological outbreak has occurred if more than two people have symptoms from the same source at roughly the same time. Written procedure are needed for dealing with an outbreak and included as part of the EAP (Emergency Action Plan) section of the PSOP (Pool Safety Operating Procedures). Inadequacies in the management approach taken with regard to swimming pools and spas has been identified as a major causal factor in a number of outbreaks in the UK. 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

An outbreak might be detected by pool staff, or may be picked up by local or national surveillance and reporting systems, such as those managed by Environmental Health Departments or the Health Protection Agency (HPA).

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

Faecal 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 should assess the risk and may decide that the risk of harmful contamination is low and allow bathing to resume. This assumes that pH and disinfection are within normal limits.

Solid faeces: 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). If there is any doubt that all the faeces have been captured and disposed of, 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 followed.

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 for, say, 30 minutes while the cleaning operation described above is taking place. Bathing should not resume until all the faeces have been removed.

All equipment that has been used in this process should be disinfected using a 1% solution of hypochlorite (1:10 dilution of commercially available sodium hypochlorite).

If the pool is operating properly with appropriate disinfectant residuals and pH values, no further action is necessary.

Runny faeces: watery, runny or soft stool (diarrhoea) is more likely to carry enteric pathogens, and be spread through the pool water. It will be impossible to remove like solid stool.

Operators are unlikely to know if Cryptosporidium is involved, so the safest option is to assume it is, close the pool and follow the procedures below.

There are in principle three procedures that will in time remove Crypto –coagulation/filtration, UV and super-chlorination. The procedures to be followed primarily depend on the efficiency of the pool's filtration.

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 oocysts 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 – see below.

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.

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 (eg 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, and 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. 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.

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, re-open.
10. 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 Cryptosporidia.

For further information on cryptosporidia outbreaks, refer to the Public Health Wales Publication: 'Guidance for the investigation of Cryptosporidium linked to swimming pools'.

Blood Contamination

Pool disinfectants should kill any pathogenic microorganisms in blood or vomit, provided disinfectant residuals and pH values are within recommended ranges. But there are some precautions to take.

Small amounts of blood, from a nose bleed say, will be quickly dispersed and any pathogens 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 spillage 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 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, which in only small quantities may be disposed of with the general waste.

Vomit Contamination

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.

PWTAG recommends that vomit in the pool should be treated as if it were blood (ditto vomit on the poolside).

Pool Plant Operations/Swimming Pool Technical Operations

These refer to the procedures required for the safe and effective management and operation of the technical aspects of a swimming pool facility, such as:

- Circulation system (pumps, valves etc);
- Filtration System (filters);
- Chemical Storage and Dosing System (chemical pumps, lines, tanks, injection points etc);
- Heating & Ventilation Systems (boilers, calorifiers, thermostats, motorised valves etc);
- Water Quality Monitoring Systems (sensors, probes, sample lines, test kits etc).

The Pool Water Treatment Advisory Group (PWTAG) have produced a code of practice, which can be used to ensure minimum standards are met. This can be downloaded from their website: www.pwtag.org.

O&M Manuals & Health and Safety Files

An O&M (operation and maintenance) manual is provided to the management of a building(s) by either the organisation that designed it, or the organisation that constructed it. It will contain details such as manufacturers' instructions and health and safety guidance, and as-built drawings and schematics of the building.

The O&M manual may form part of the Health and Safety File that a Principal Designer, or Principal Contractor is required to hand over to the Client at the end of a construction project under the Construction (Design and Management) Regulations 2015.

The O&M Manual and Health and Safety File should be used as resources to help inform risk assessments, which in turn inform risk control systems, safe systems of work 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.).

They can also be used to help in training staff on the layout and operation of the pool plant system.

03. Pollution

Relative Pollution

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. Examples are:

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

Bather Load and Turnover Period

The more bathers in a body water (bather load), the more pollution will be introduced (all other factors being equal) 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 and the time it takes to move water around the system 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.

Bather Load

It is important that pool operators do not over load a pool with bathers. It makes it difficult for lifeguards to spot people in trouble and it also has a negative impact in the quality of the pool water.

Pool operators need to establish two different types of bather load:

1. Instantaneous bather load
2. Total daily bather load

In order to calculate the **instantaneous bather load**, the following formulae should be used:

- For water that is under 1.0m deep, each swimmer should have $2.2m^2$ of surface area each
- For water that is 1.0 – 1.5m deep, each swimmer should have $2.7m^2$ of surface area each
- For water that is over 1.5m deep, each swimmer should have $4m^2$ of surface area each

As an example, for a swimming pool that is:

- 20m long;
- 12m wide;
- with a deep end that is 2.0m deep and ;
- a shallow end that is 1.0m deep…

…the bather load would be calculated as follows:

- Shallow End: 10m x 12m / 2.2m = 55 bathers
- Deep End: 10m x 12m / 4.0m = 30 bathers

The total instantaneous bather load for the whole pool would therefore be **85 bathers** at any one time.

In order to calculate the **total daily bather load** the following formula should be used:

- Instantaneous bather load x 25 – 50% x 12

As an example for the same swimming pool as above:

- 85 x 25 – 50% x 12 = **255 - 510 bathers per day**.

Pool operators should only go to the upper end of this 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.

Turnover Period

In order to achieve the correct turnover period, the circulation pumps need to be pumping water around the system quickly enough. The rate at which the water is moving around the system is called the flow rate. A rough guide when designing and sizing swimming pool circulation systems is to multiply the instantaneous bathing load (referred to earlier) by 1.7 to give a target flow rate to aim for. Therefore, using the example from earlier, the target flow rate can be calculated as follows:

- 85 x 1.7 = 144.5 m^3/hr

Pool operators should ensure that the pool water is being circulated quickly enough by establishing and documenting the turnover period, that is; the amount of time it takes to for a volume of water equal to the pool volume, to pass through the system. This is done by dividing the pool volume by the flow rate. The flow rate is simply the rate of flow of pool water through the system, usually expressed as cubic metres per hour (m3/hr). See the worked example below:

- Pool Volume - 300m3
- Flow Rate - 144.5 m3/hr
- Turnover Period - 2 hours

Flow rates and turnover are discussed in more detail in the 'Circulation' chapter.

Physical Pollution

Physical pollution is one of the three main categories of pollution that concerns pool plant operators (the other two being chemical and biological). Physical pollution is made up of contaminants that do not dissolve in the water:

- Dirt
- Grit
- Sand
- Plasters
- Bits of float

Lighter physical pollution will float on the surface of the water, where it can be removed via the following methods:

Netting – using a long handled pole with net attachment

Scooping – using a long handled pole with scoop attachment

Skimming – the top layer of pool water is removed via the surface-water-draw-off-system (either scum trough, skimmer basket, or deck-level)

Heavier physical pollution will sink to the bottom of the pool and will settle on the bottom, where is 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, where it will be removed via the filtration system.

Chemical Pollution

Chemical pollution refers to all chemicals that are dissolved or suspended in the swimming pool water. There are a large number of different chemicals that are introduced into the water, 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:

- Disinfectant (e.g. chlorine)
- Disinfectant by-products
- pH correctant (e.g. Acid)
- pH buffer (e.g. Sodium bicarbonate)
- Calcium harness increaser (e.g. Calcium chloride)
- Calcium minerals (i.e. hard water)
- Cosmetics (e.g. de-odorants etc.)
- Urine
- Sweat
- Mucus

It is worth noting that much of the chemical pollution is caused by the addition of treatment chemicals (chlorine, pH correctant etc.) and that 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 under-estimated.

Total Dissolved Solids (TDS)

The levels of chemical pollution present in the pool water can be measured using an instrument called a 'Total Dissolved Solids' meter (TDS meter). This measures the electrical conductivity of the pool water. As pure water is not a conductor of electricity, the more conductive the swimming pool water is, the more it must contain by way of elements other than water, i.e. it is the chemicals dissolved within the swimming pool water that is conducting the electricity, not the water itself.

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.

Source Water

There can be several different sources of water to fill swimming pools, some examples:

- Boreholes
- Wells
- Springs
- Lakes
- Reservoirs
- Lakes

Water can be supplied to a location in two main ways:

- Supplied by water companies
- 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 ask for copies and use the information as a key input into the pool water treatment regime.

Alkalinity

Alkalinity is a measure of the alkaline salts dissolved in it and has an influence on how resistant the water is to changes in the pH value. The higher the alkalinity level, the more resistant the water is to changes in pH. There is more detail on this on chapter 10. pH Control.

Hardness

Total hardness is a measure of the calcium and magnesium salts dissolved in it. Calcium hardness is the part of total hardness that consists of calcium salts and has an influence on how corrosive or scale-forming the water is.

Sulphates

Sulphates are salts of sulphuric acid that occur widely in everyday life and will therefore be present in pool water. High sulphate levels in combination with high TDS levels can attack cement and grout, so they need to be controlled to be lower than 360mg/l. If this is not possible (due to high usage of sodium bisulphate and aluminium sulphate), sulphate-resistant Portland cement and epoxy grout may be required to resist sulphate attack.

Bather-Added Chemicals and Disinfection By-Products

Sweat and urine from bathers are nitrogenous products that will form ammonia through decomposition. When chlorine reacts with ammonia, chloramines are formed. There are potentially three stages:

1. Monochloramine (Chlorine + Ammonia)
2. Dichloramine (Chlorine + Ammonia + Monochloramine)
3. Trichloramine (Chlorine + Ammonia + Monochloramine + Dichloramine)

Chlorine will also react with and oxidise nitrogenous compounds (the precursors to ammonia; mainly urine and sweat). These reactions form irritant chemical by-products and are also a waste of chlorine (which is needed for disinfection of biological pollution, such as harmful bacteria).

Trihalomethanes (THM's) are organic compounds that occur in swimming pools as a by-product of the reaction between chlorine and bather-added pollution such as sweat and urine. They can also arise in source water due to the reaction between humic acid and disinfection compounds. THM's can be found both in the swimming pool water and in the air above it, giving rise to several routes of entry into the body (skin contact, ingestion and inhalation). THM's have been associated with an increased risk of bladder cancer and studies have suggested that it is reasonable to assume that exposure to high levels of THM's for long periods may present some poorly defined risks to pregnant women.

Swimming pool should aim to operate with THM's at less than the UK drinking water standard of 100 micrograms per litre. However, monitoring for THM's is difficult and expensive, so does not form part of the routine monitoring regime for swimming pools. Pools managers should be mindful of THM's though and seek to control levels by adopting procedures to encourage pre-swim showering, control of bather loading and responsible use of disinfectants (as little as will get the job done and an avoidance of shock-dosing).

Biological Pollution

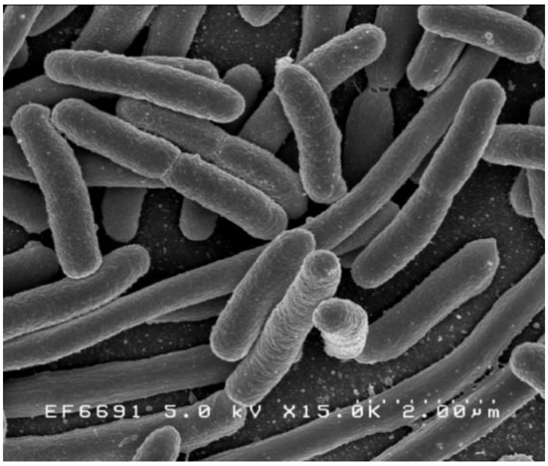
Biological pollution is any pollution that is a living organism. Examples below:

- Bacteria
    - e coli
    - legionella pneumophila
    - pseudomonas aeruginosa
- Protozoa
    - cryptosporidia
- Algae

Biological pollution is particularly hazardous to bathers as it can cause a number of infectious diseases, some of which can be fatal. It is introduced into the swimming pool water in a number of ways. A few examples are given below:

- 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. The most common way of disinfecting swimming pool water in the UK is by the addition of 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.

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

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

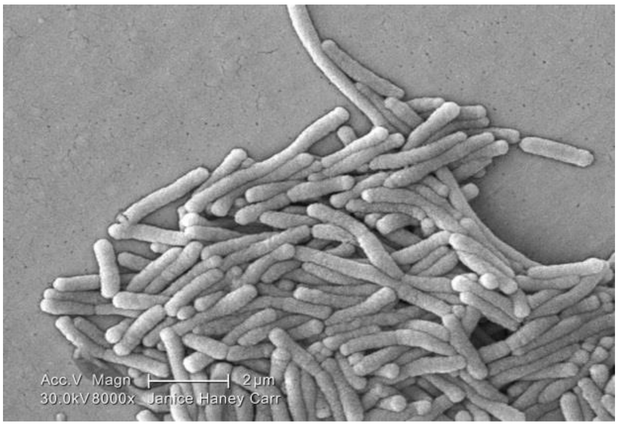
Protozoa with similar characteristics to cryptosporidium.

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

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.

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.

Well-operated pools should not normally contain P. aeruginosa. If the count is over 10 P. aeruginosa per 100ml, repeat testing should be undertaken. Where repeated samples contain P. aeruginosa the filtration and disinfection processes should be examined to determine whether there are areas within the pool circulation where the organism is able to multiply.

There is a risk of an outbreak of folliculitis when the count exceeds 50cfu/100ml so the pool should be closed, remedial action taken and the water resampled.

High numbers of pseudomonas aeruginosa can also cause the condition otitis externa, which is an infection of the outer ear. This condition is sometimes known as swimmers ear and can also be caused by the wetting, dewaxing and degreasing of the outer ear.

Pseudomonas aeruginosa can readily infect plastic and inflatable items of pool equipment, such as blow-up play features, armbands, flotation aids etc. Equipment such as this should be cleaned regularly with a 10mg/l chlorine solution. Inflatables should be dried out prior to being folded up and staked away in order to avoid moist areas where the bacteria can proliferate.

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.

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 four standard tests and the acceptable levels for each are:

- Aerobic Colony Count < 10cfu/ml
- Total Coliforms <10cfu/100ml
- E. Coli <1cfu/100ml
- Pseudomonas Aeruginosa <10cfu/100ml

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.

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.

Total Coliforms

Total coliforms are a particular type of bacteria. They exist in animal (and human) intestines as well as being present in the environment (on vegetation and in soil). The presence of total coliforms in the water may indicate that faecal or environmental contamination.

E. Coli

A type of coliform bacteria. This particular type of bacteria cannot multiply in water, but they are normal inhabitants of the intestinal tract. Therefore, the presence of this bacteria in the water is an indication of faecal contamination.

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.

Gross Microbiological Contamination

What if the results are way outside the acceptable ranges though? At what point does the pool operator need to close the pool down due to gross microbiological contamination? The official guidance is that the pool should be closed down if any of the routine 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)

You may find microbiological test reports easier to interpret by referring to the flow chart at Appendix 5.

Legionella

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 are 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.

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.

Pre-Swim Hygiene

All sorts of things can go wrong with swimming pool water for any number of different reasons. Things can get out of hand very quickly if you don't know what you're doing. However, there is one key variable that can have a dramatic influence on the quality of your pool water. Get this issue right, and you will experience far fewer problems with regard to pool water quality, you'll spend far less money on expensive chemicals and you and your duty managers will spend far less time trying to resolve issues. What's more, to implement and control this issue is very easy and simple to do and will hardly cost you anything in time, money or effort. So, what is this issue that can have such a dramatic effect? Pre-swim showering!

You should look at your pre-swim showering policy and consider the following facts:

1. the pollution on bather bodies is what makes up most of the pollution into the pool
2. the remainder of the pollution only exists in the first place because of the chemical reactions resulting from the chemicals you are having to add to deal with 1.
3. pre-swim showering removes most of the pollution on bathers
4. 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, that they are warm, and that they are 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 situated conveniently so that swimmers are not discouraged from using them.

Exclusion of Swimmers

Parents should be encouraged not to bring children under the age of 6 months to public swimming pools where they share the water with other general swimmers (unsuitable water temperatures and pool water chemicals may affect sensitive skin). Ideally, young children’s pools should be provided with separate water treatment and filtration and should be able to be emptied in the event of a faecal fouling incident.

Very young children should use special swimming nappies, which are 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 which are emptied regularly.

Control entry using notices at reception saying that people with diarrhoea must not swim – then, or for 48 hours afterwards. Those who have been diagnosed with cryptosporidiosis must not swim for 14 days after diarrhoea has stopped.

04. Swimming Pool Environment: Design, Cleanliness and Hygiene

There are specific sources of information, listed below, from which the technical design and planning standards that are recommended in the design of swimming pools can be obtained.

- HSG179 Managing Health and Safety in Swimming Pools
- PWTAG Swimming Pool Water: Treatment and Quality Standards for Pools and Spas
- PWTAG Code of Practice – Swimming Pool Technical Operations
- BS EN 15288 1: Swimming pools. Safety requirements for design.
- BS EN 15288 2: Swimming pools. Safety requirements for operation.
- Sport England design guide

Everyone who is involved in the process of specifying, designing and constructing pools should be familiar with these design and planning standards and should ensure that they are given careful consideration in all pool projects.

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 decide 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.

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.

Access to the pool and the pool hall

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.

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.

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 in all wet areas, pool surrounds, showers, changing rooms and toilets to tackle a build-up of lime scale 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 that no residue from these cleaning programmes returns to thepool 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

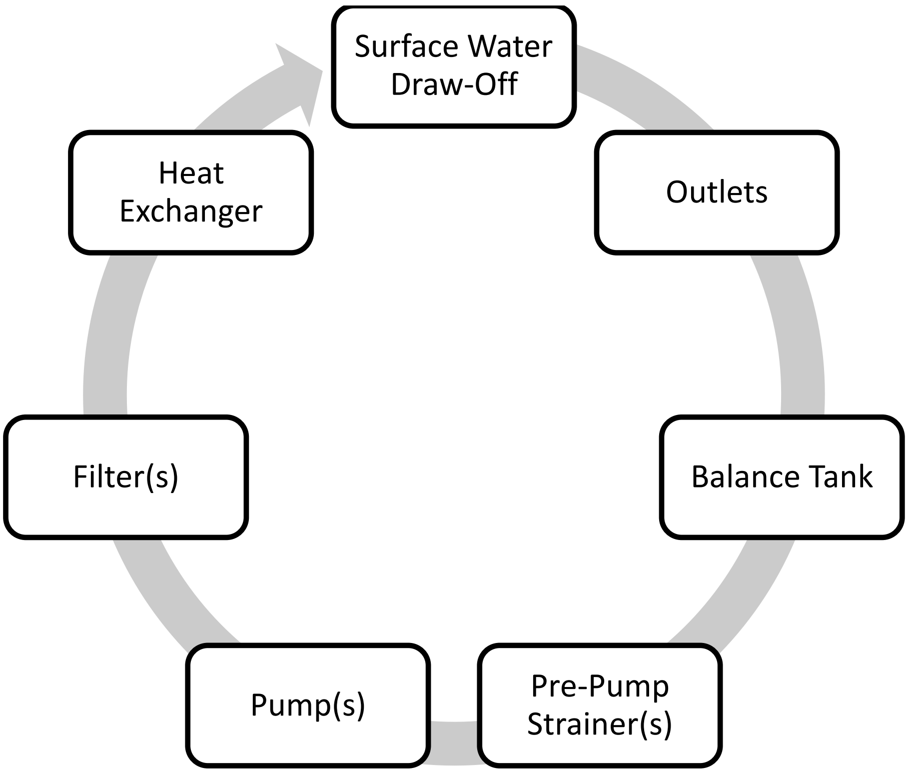
Stainless steel fitting and fixtures should be cleaned whenever it has lost its original appearance. How often this is required will vary, some elements may require daily cleaning, others may require only annual cleaning. Detergent is not normally required (water will suffice, unless there is a build-up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

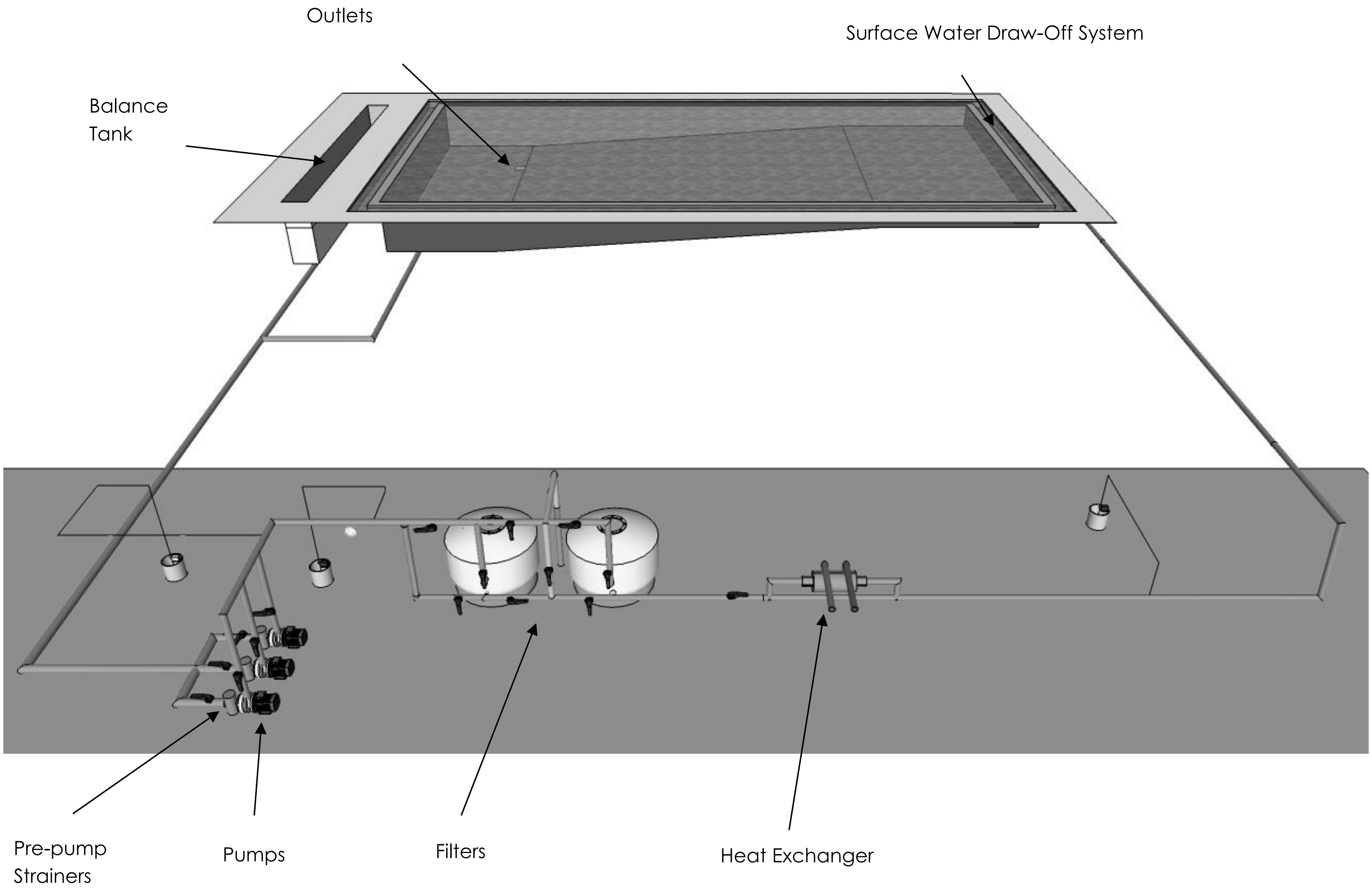
05. Main Features of a Pool Plant System

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:

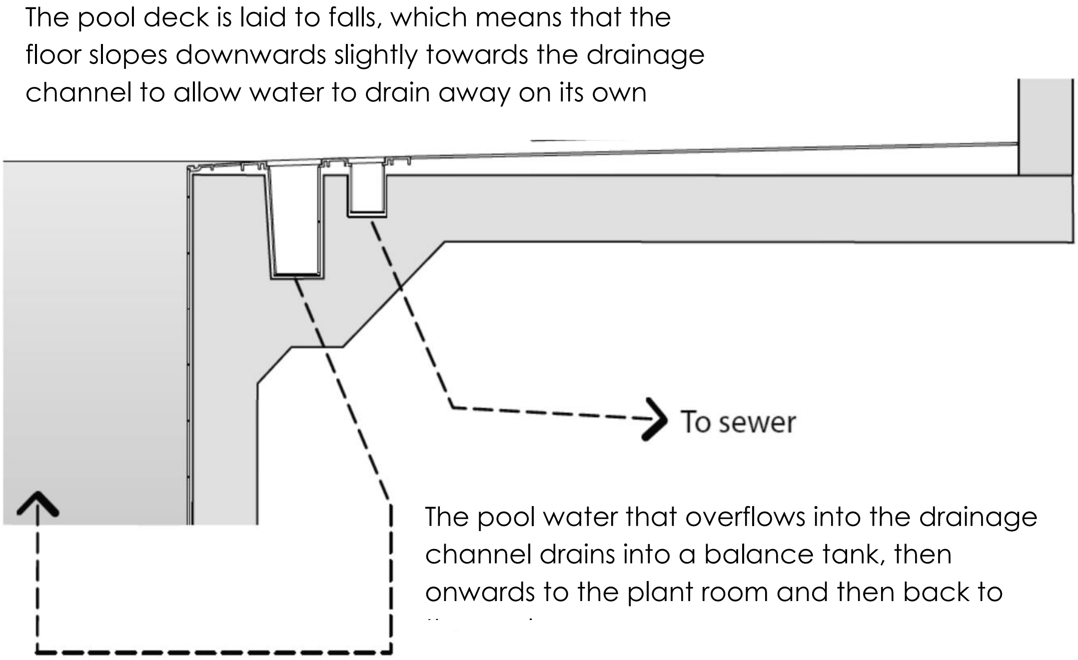
- Deck-level
- Skimmer
- Scum trough

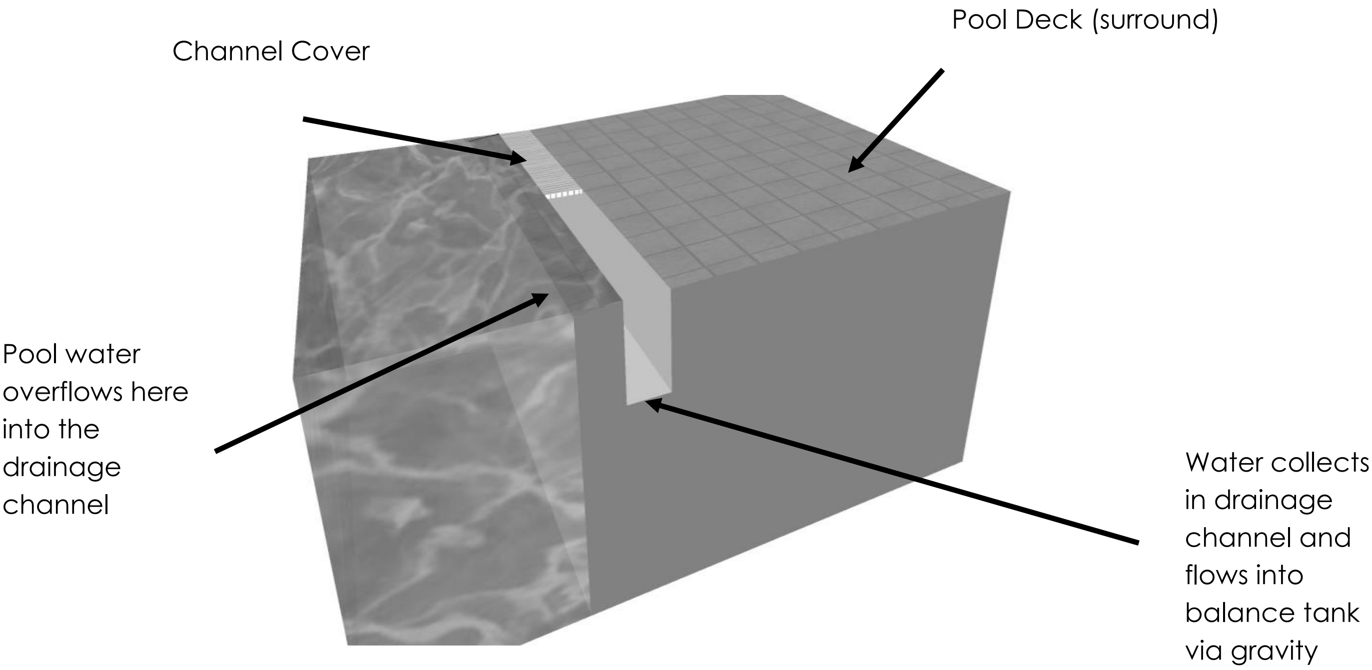
Which system is installed on a pool is largely down to when the pool was built. Deck-level systems are the newest type, scum trough systems are the oldest. Each system has varying degrees of effectiveness at removing surface water pollution. How much pollution is removed is dependent on how much water 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.

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

Deck-Level System

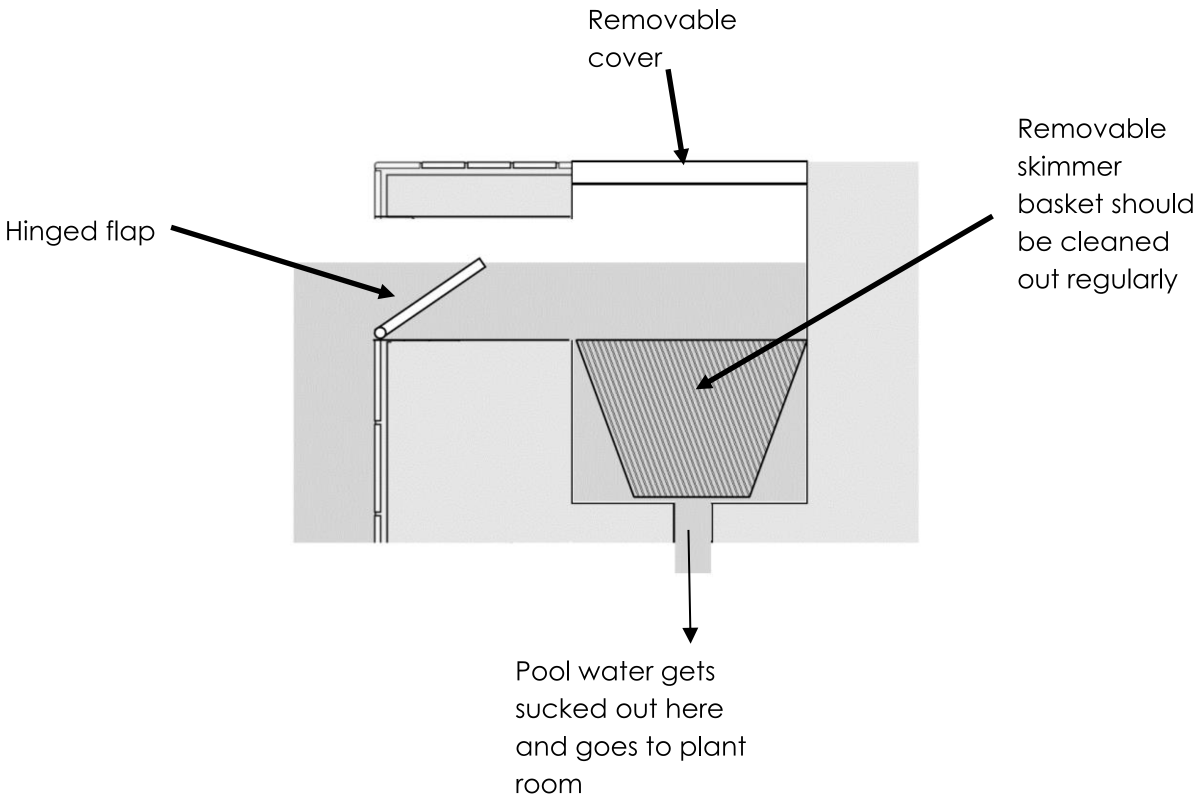
The surface of the pool water is level with the deck of the pool, with water constantly overflowing into a drainage channel which goes around the perimeter of the pool. This is a very effective system for removing pollution on the surface of the water. With this system, 80% of the pool water leaving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

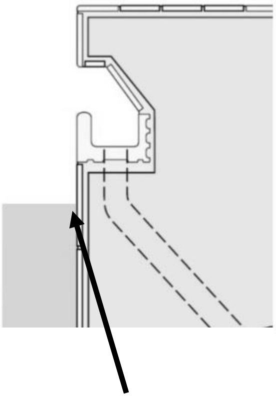
Skimmer Basket System

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

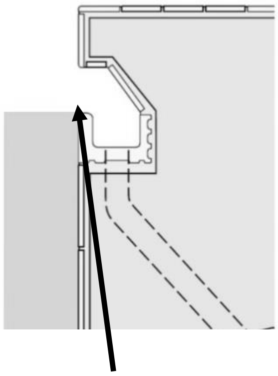


Scum Trough System

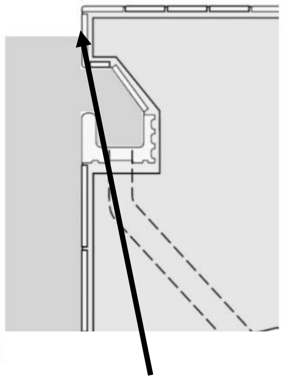
With this system, the pool water overflows into a trough that is built in to the pool wall. Providing that the pool water level is at just the right place, the water will overflow as intended, thus removing the surface water pollution. If however, the pool water level is too high, or too low, the water 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.

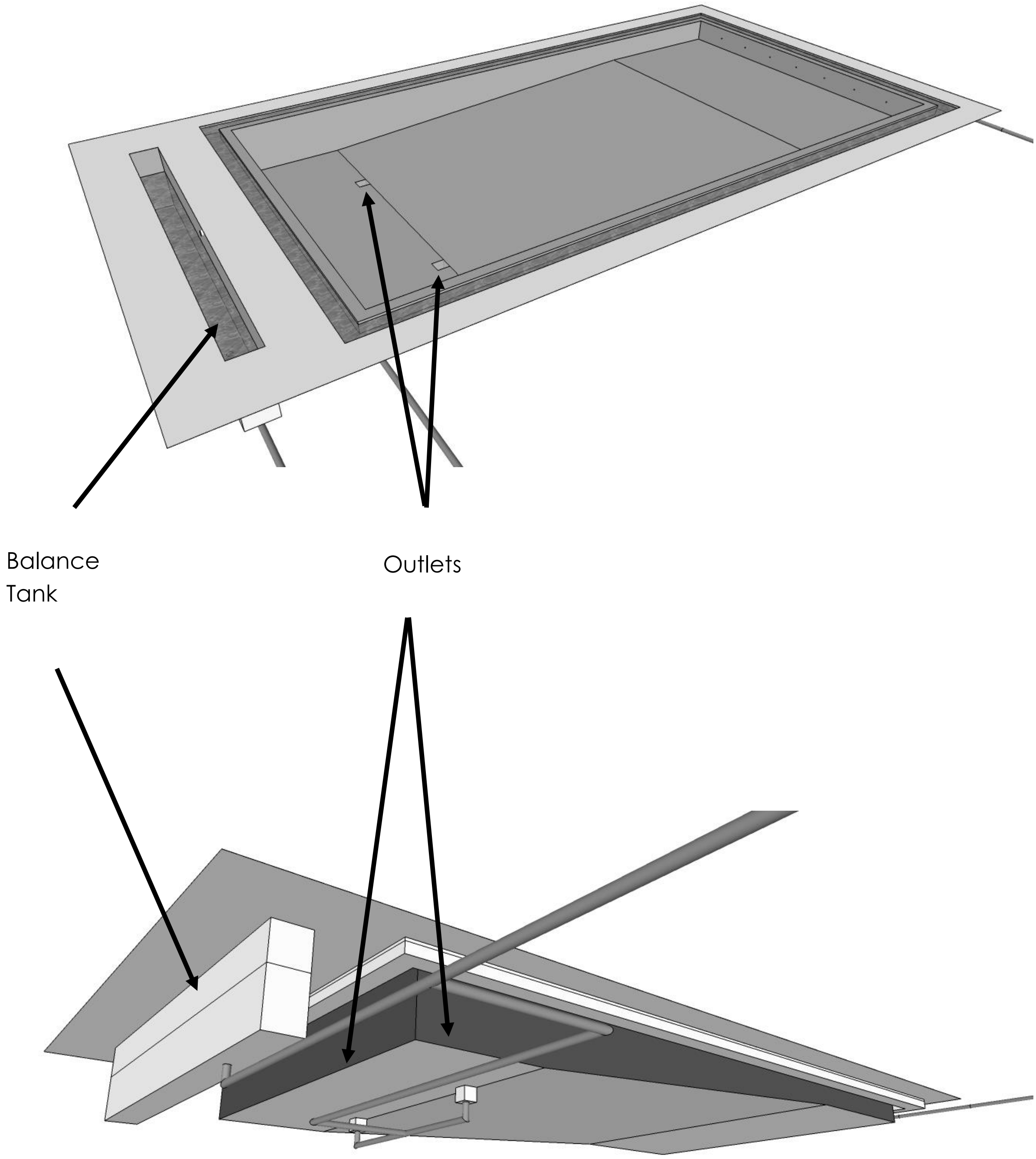
- Drape the towels over the length of the rope while it's lying on the poolside.
- Get one person on each side of the pool and slowly drag the rope down the length of the pool, from shallow to deep.
- What you should see is the towels acting as a filter/barrier. It will catch some of the smaller particles 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)

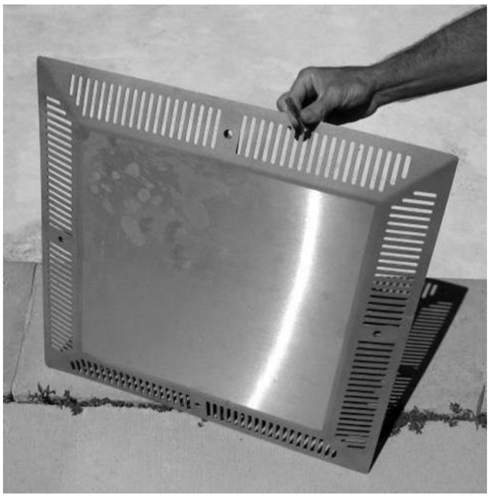
The outlets of a swimming/spa pool can be extremely hazardous. The hazards are groups under the headings of entrapment hazards and entanglement hazards.

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.

Delivery
Side

Suction
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 in order to prevent bathers becoming infected by it.

Chemical by-products of the disinfection process will also remain in the swimming pool water until they are filtered out, not to mention physical pollution such as dirt and sand etc.

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.

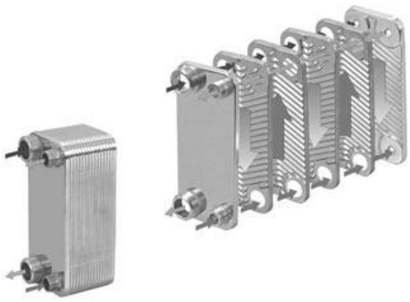
Sedimentation

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

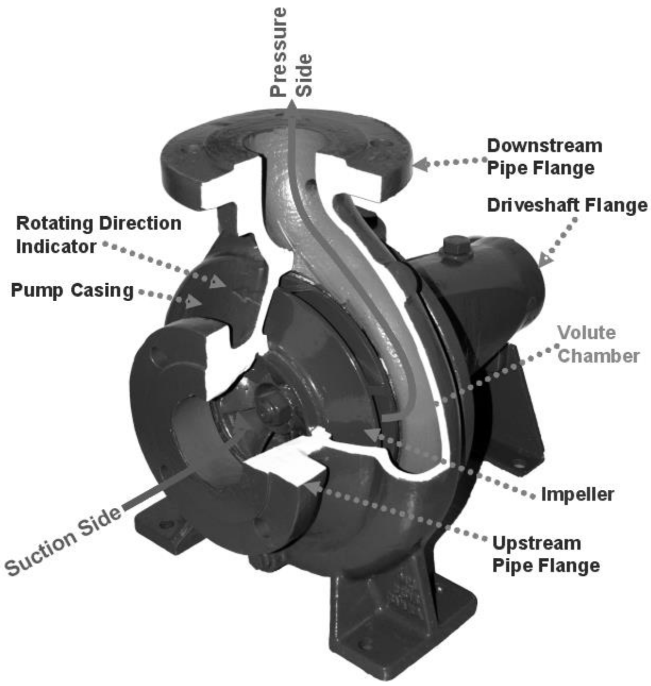
 

Multi-port valves

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.

06. Circulation

In days gone by, swimming pools were not provided with any type of system for circulating the water around. They were referred to as 'fill and empty' pools. Once the water was dirty, the pool was drained and refilled. Nowadays, swimming pool water is constantly circulated around a circuit so that it can be filtered, heated and chemically treated before being recirculated back into the pool.



The job of moving the water around is that of the circulation pump(s). Most circulation pumps work via a centrifugal action. An outer casing encloses an impeller that when rotating, causes water to be drawn in via vacuum suction. On the other side of the impeller, the water is under pressure and thus gets forced along the pipework. The pumps need to be primed (i.e. flooded with water) at all times in order for this to happen.

Flow Rate, Turnover Time and Pool Volume

Flow rate is an important piece of information that a pool plant operator needs to know. It refers to the speed at the pool water is circulating around the system and is usually expressed as m^3/hr, meaning cubic metres per hour. Sometimes the flow rate is given as gallons per minute (GPM) or litres per minute (LPM). Without knowing the flow rate, you will not be able to calculate the turnover time of the pool, which refers to the amount of time it takes for the pool volume to go through the circulation system. Flow meters should be maintained and calibrated on a regular basis to ensure that the information they provide is accurate.

Flow Rate

- The speed at which water is travelling through the circulation system
- Usually expressed as cubic metres per hour (m3/hr)

Turnover Time

- The time it takes for a volume of water equivalent to that of the pool contents to make one pass through the circulation system.
- Usually expressed as hours and/or minutes

Pool Volume

- The volume of the swimming pool

- Can be calculated by multiplying the length by the width by the average depth
- Usually expressed as cubic metres (m3)

For example, if you were operating a swimming pool that is 25m long, 12m wide, with a 0.9m shallow end and a 1.9m deep end, the pool volume would be worked out like this:

25m	x	12m	x	1.4m	=	420m3
Length		Width		Av. Depth		Volume

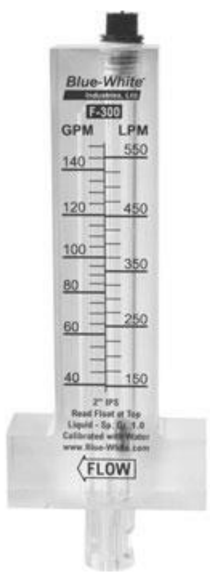
If the flow rate was indicated as being 150m^3/hr, then the pool turnover would be calculated like this:

420m3	/	150m3/h	=	2.8 hours
Volume		Flow Rate		Turnover Time

As can be seen, it would be impossible to calculate the turnover time, without knowing the flow rate. Therefore, all pools should ideally be fitted with a flow rate meter.

This flow rate meter displays the information as cubic metres per hour (m^3/hr).

This one displays the information as gallons per minute (GPM) and litres per minute (LPM). To convert litres per minute to cubic metres per hour, multiply the litres per minute by 0.06.



If the turnover time of a pool is too long, pollution levels will start to build up. If the turnover time is too short, the water will be travelling too fast through the system and this will have a negative impact on the effectiveness of the filtration system (slower filtration is usually better than faster filtration).

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

The turnover of water in shallow areas may be designed to be higher than in other areas. The turnover period of pools with moveable floors should be appropriate to the pool at its shallowest point (ie potentially biggest bathing load).

Pools with restricted access and thus bathing load (eg school, hotel, health club) may operate with a longer turnover period than indicated here, but the turnover rates given above should not be reduced where public use is introduced (eg dual-use school pools).

Pool water should circulate and be treated 24 hours a day. If the pool has a moveable floor or bulkhead (boom), the circulation system should ensure proper water distribution in all possible positions. Good circulation hydraulics are necessary to ensure that the whole pool is adequately served in terms of both disinfection and removal of pollutants.

The circulation rate and turnover rate established in accordance with the guidelines here should form the basis, along with water velocity and inlet and outlet issues, for the specification of circulation hydraulics, including pumps and pipework.

Single or Multiple Pumps

It is usually advantageous to have more than one single circulation pump fitted to the system. By having two or more circulation pumps fitted, you have a 'back-up' as and when the circulation pumps require repair or replacement. If you only had one pump, you would have to put the pool out of use if it stopped working properly for any reason whilst the necessary repairs are carried out.

Another good reason for having multiple pumps is to save money on energy costs. Going back to the example of the pool that was used in the previous section, if we needed to achieve a turnover time of 3 hours, the flow rate would need to be 140m^3/hr. This is worked out as follows:

420m3 / 3 hours = 140m3/hr

If only one circulation pump was installed on the system, then that pump would need to be powerful enough to deliver this flow rate. If we had two smaller pumps installed, and ran them together at the same time in order to achieve the desired turnover time, we have given ourselves the option of turning one of those pumps off overnight when the pool is not in use. This would slow down the turnover time, which would give us much better for filtration efficiency. It would also allow us to make significant cost savings over the course of a year. The amount of money that can be saved can be calculated by referring to your electricity bill and looking at the amount you are charged per kilowatt hour and then multiplying this figure by the number of hours you are able to switch one of the pumps off for over the course of the year.

Variable Speed Drives

An alternative method for making cost savings in relation to circulation is the use of variable speed drives (VSD's). These are devices that are interlinked to the power supply to the pump(s) that have the ability to alter the speed of the pumps (and therefore, reduce the costs) in response to changing conditions in the pool.

Circulation for Multiple Pools

Many buildings have more than one wet-side facility in the premises. It is not uncommon to see learner pools adjacent to main pools for example, or a leisure pool may have a spa pool off to the side.

In these situations, the ideal would be to have separate circulation systems for each pool. The pool operator will have more control that way and would be able to isolate a pool if it were to be contaminated, thus avoiding spreading the contamination to the other pool.

If the above ideal scenario is not the reality, and more than one pool shares a common circulation system, pool operators will need to mindful of the fact that pollution in one of the pools will have an impact on all of the pools on that circulation system. For example; if there were a cryptosporidia infection in one of the pools, the pool operator would need to evacuate and close all pools sharing the circulation system, not just the pool that was initially contaminated.

Dye Tests

In order to check that the pool circulation system is doing an effective job of distributing the water in accordance with the design parameters, pool operators can carry out a test by adding a special dye into the circulation system (usually via a chemical dosing pump or strainer pot).

The dye then colours the pool evenly within a specified time frame (usually 15 minutes) in order for the circulation system to be deemed satisfactory.

The pool water needs to be de-chlorinated prior to the addition of the dye (with sodium thiosulphate).

The dye also needs to be chosen carefully to ensure that it is compatible with the surfaces it will come into contact with and will not leave behind permanent staining or residue.

07. Filtration/Coagulation

Filtration is an important element of effective pool water treatment. The basic principle is that the untreated water is passed through a filtering medium (such as a bed of sand). The water is able to pass through the gaps between the grains of sand (called 'pores'), but anything larger than the pore size is trapped within the filtering medium.

This element of the manual will discuss sand filtration primarily, with some summary information at the end of the chapter about other types of filtering medium.

Pool Water Clarity

A reduction in the clarity of the pool water is a risk to pool users. It is essential that bathers are able to assess the depth of the water and for lifeguards to see a casualty below the surface of the water. If the water clarity falls below a stated level (defined in the EAP), the EAP should identify the procedures for suspending admissions and clearing the pool until the clarity reaches an acceptable level (as a minimum, the ability to see the body of a small child if it were located on the floor of the pool in the deepest water). The clarity of the pool water should be constantly monitored.

The pool water treatment system should be capable of providing clarity of no more than 0.5 nephelometric turbidity units (NTU).

Clarity is reduced by turbidity – colloidal or particulate matter in suspension in the water. It is important to know the source of excess turbidity – whether pollution from bathers, external contamination, inadequate circulation/turnover or disinfection, or incorrect use of water treatment chemicals – in case this can be dealt with directly. The likeliest remedy, however, is adequate filtration and backwashing, coupled with coagulation.

Filter Design and Construction

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

- Mild steel
- Stainless steel
- Plastic
- Concrete

The most commonly used is mild steel. The inside surface is lined with either rubber or epoxy paint in order 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.

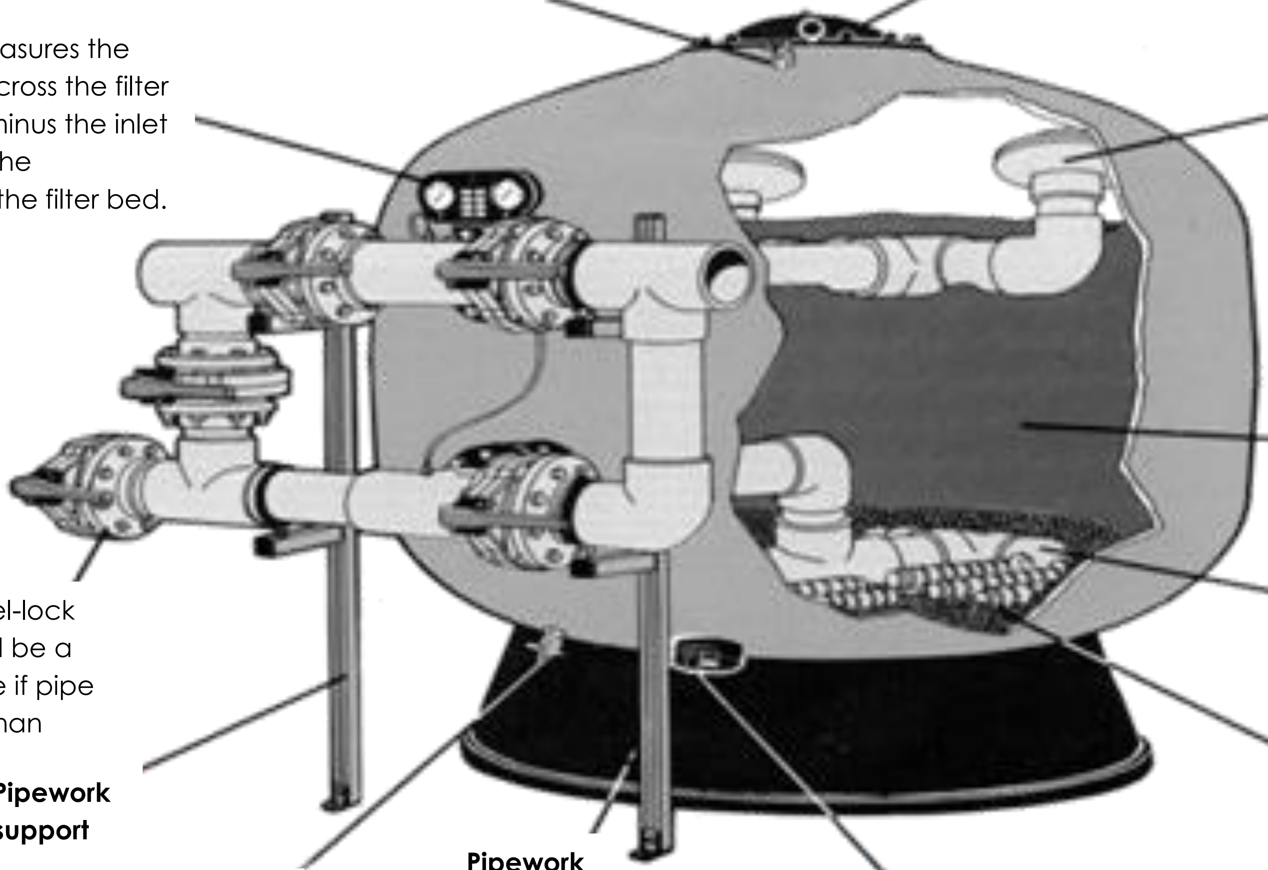
The filter media bed may need to be replaced every 5-10 years, depending on its condition during the routine annual inspections. This provides an opportunity to inspect the underdrains for damage and repair or replace as needed. Deposits of sand on the pool bottom can be a sigh of damage to the underdrain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

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

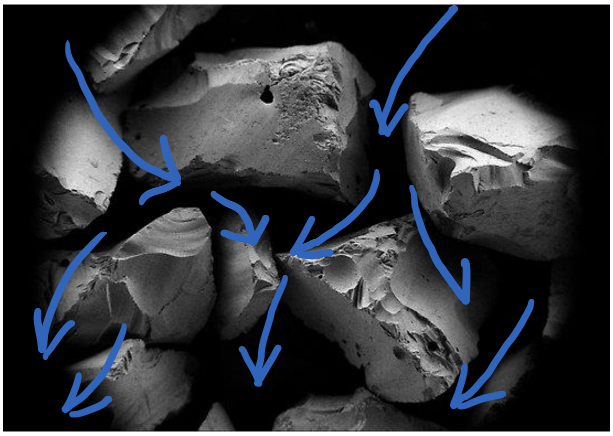
Drain valve

Pipework support

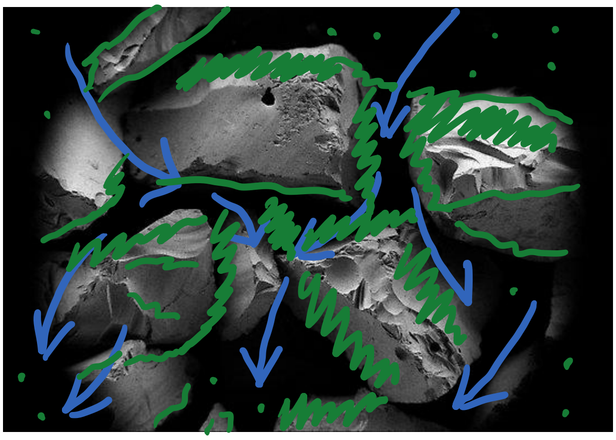
Sand Drain Flange

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.

The basic sand filtration process work as follows:



Water moves in a downward direction through the filter and gets passed through the pores between the sand grains. This is illustrated by the blue arrows



Pollution within the water becomes entrained within the sand bed layer via processes of sedimentation, adsorption and mechanical straining. This is illustrated by the green areas.

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 = 1000 microns). Anything too big to pass through the pores will become entrapped, anything smaller may pass through unless they settle on the upper-facing surface of a sand grain, or they stick to the surface of a sand grain via adsorption.

Sedimentation 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 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.

Filtration Rates

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:	2.7 metres (this is also the diameter)	
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 and they are 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

Backwashing is the process of cleaning the filters. Consider that the job of the filters is to trap as much of the various types of pollution as possible and you will appreciate that over time, more and more of this pollution will build up within the filter media. At regular intervals, this accumulated pollution needs to be cleaned away from inside the filter(s). The method by which this is achieved (backwash) involves reversing the flow of water through the filter, so that instead of water going in at the top and coming out at the bottom, the water goes in at the bottom and out at the top. As it does this, the pressure of the water moving up through the sand in the filter causes the sand to break up and 'fluidise'. When this happens, the pollution is dislodged and is forced out of the sand and through the top of the filter media bed. From there it is directed to the drains (NOT back into the swimming pool!).

It is a fairly simple and straight-forward process, and there should be a step-by-step guide contained within your Normal Operating Procedure (NOP) or systems of work etc. to guide you through it. For the pool plant operator, it is recommended that they get to know their pool plant system well enough that, eventually, they will not need to refer to a guidance document in order to properly perform a backwash. A very simplified, generic backwash description is given below:

1) Switch off circulation and chemical dosing.

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

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

4) Switch circulation off.

5) 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).

6) Switch circulation back on and leave running for a couple of minutes (this is called the 'rinse'.

7) Switch circulation off.

8) Adjust valves so that the pool water goes in at the top and out at the bottom, but this time returns to the pool.

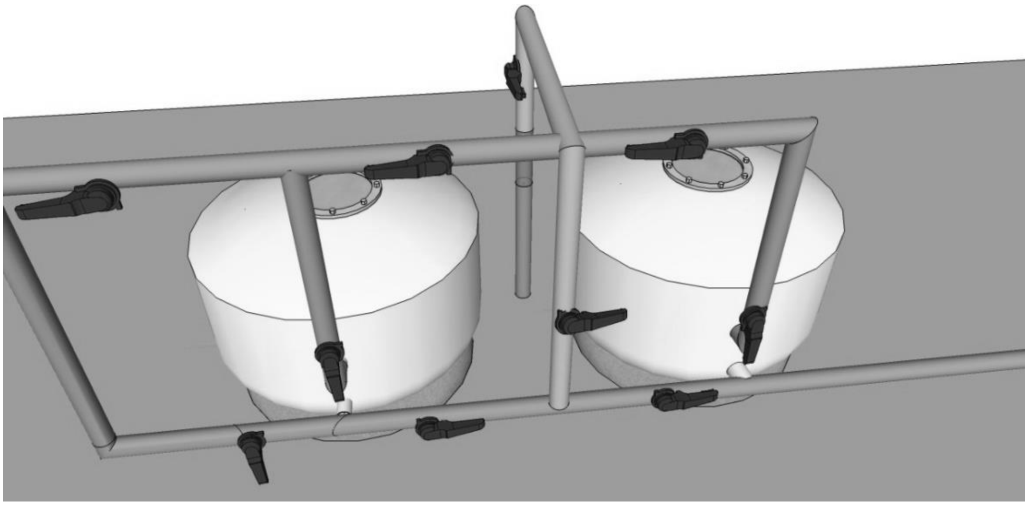
9) Switch the circulation back on and pen the air release valve to purge the system of trapped air.

Air Scouring

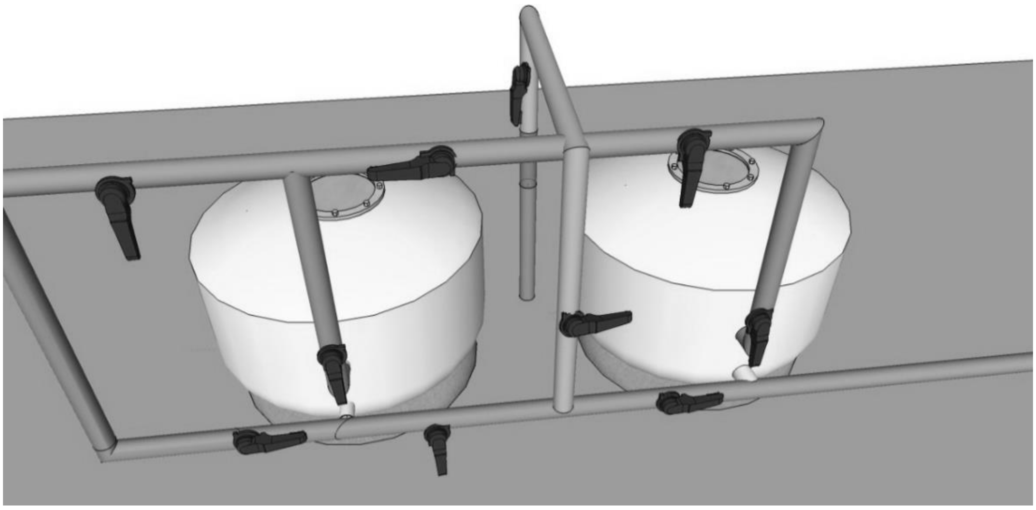
Air scouring is a process of forcing air up through a filter bed prior to backwash to expand the filter media and loosen dirt particles. An air scour rate of about 32m/h is desirable to aid backwashing. Not all pool plant systems have an air scour system as part of the original installation, but they are possible to retro-fit 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.

If you have the filter manufacturer’s instructions, refer to those as they will inform you of how often a backwash needs to take place. What happens to a filter over time is that as it does its job and collects within it all the pollution and contaminants that you don't want getting in your pool, it becomes blocked up. This process is actually helpful towards the beginning of the cycle as it causes narrower gaps

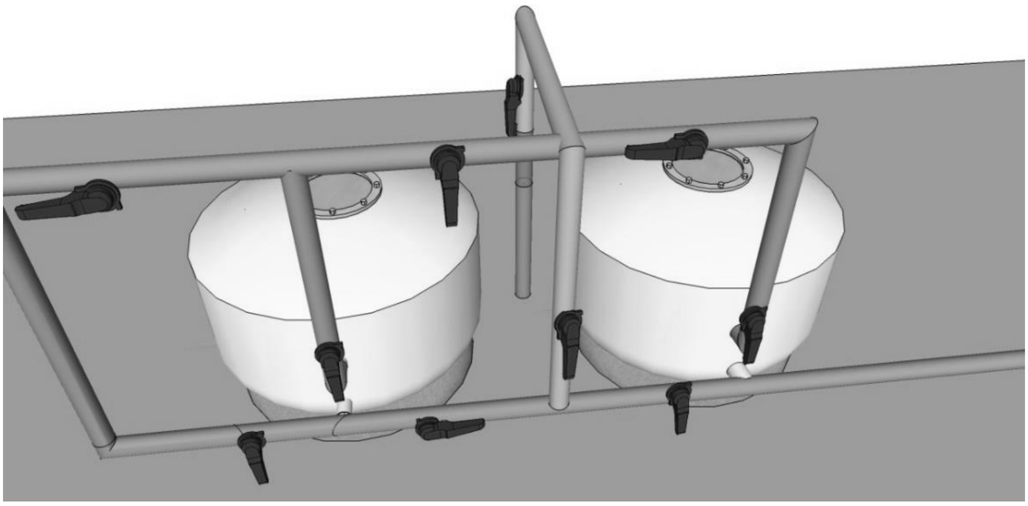
between sand grains (known as pores). This means that the filter will be capable of trapping smaller particles. This process is known as 'filter ripening'. As this process is happening, the resistance to flow encountered by the pool water as it enters the top of the filter will increase. At the same 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 located on the inlet and outlet of a filter and 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 and 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, but keep an eye on the pressure differential and review the policy if needs be. It is important that the pressure gauges are maintained and calibrated regularly to ensure that the information that are providing is accurate.



Valve configuration during normal filtration



Valve Configuration during backwash of filter



Valve configuration during rinse

Other types of filter and filtering medium

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.

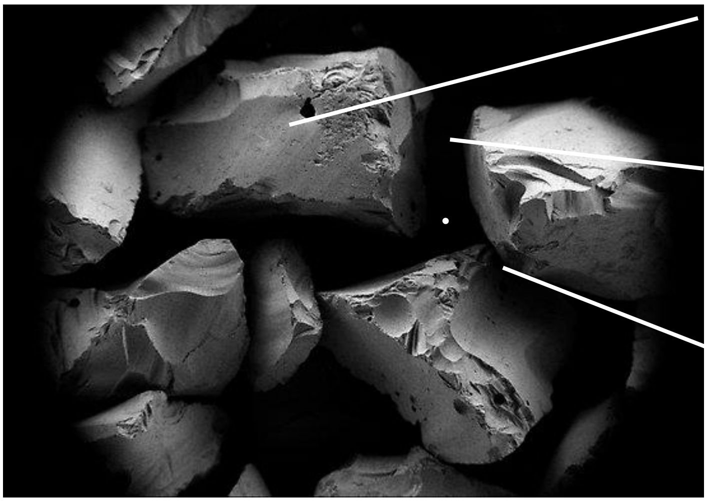
Membrane filters take up less floor space than sand filters and there is the possibility that they could be used to ‘recycle’ backwash water, so instead of discharging it to drainage, it could be recirculated back into the system, thus providing potential costs savings. The Pool Water Treatment Advisory Group (PWTAG) are hoping to organise trails on the potential application of this type of filtration in UK swimming pools.

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.

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 are 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

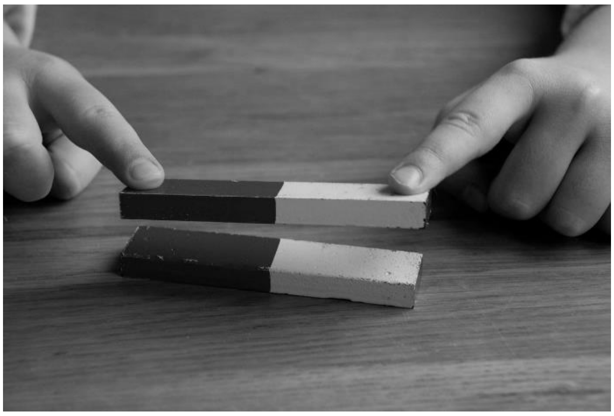
Average pore size 50 – 70 microns

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

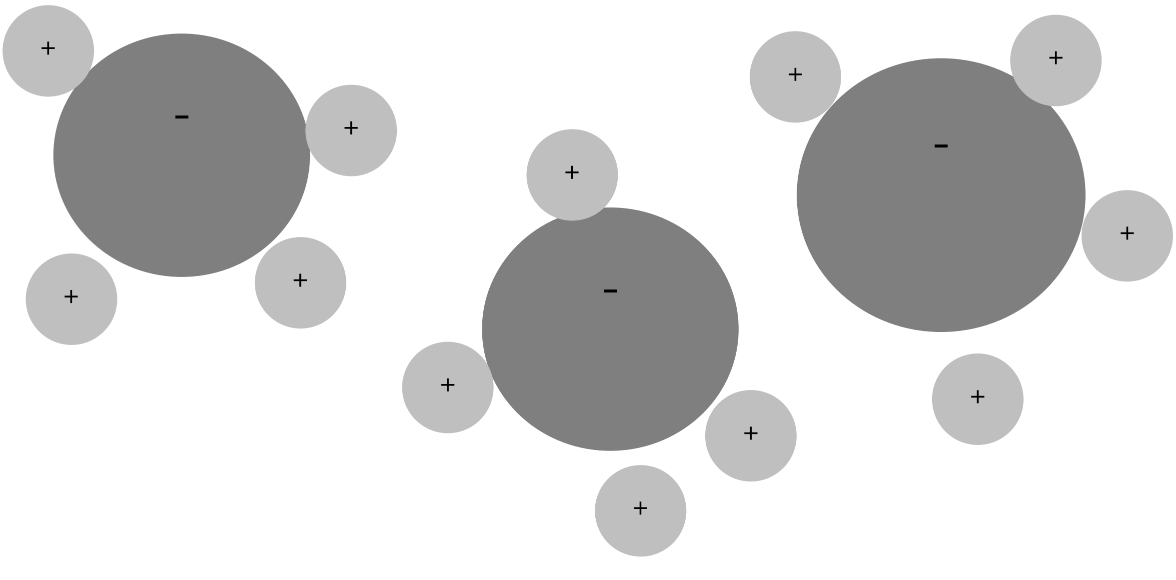
As the filter begins to trap particles, the size of the pores decreases. This is known as 'filter ripening'. When the filter is fully ripened, it will be capable of straining particles the size of around 5 - 10 microns. The size of cryptosporidium cysts are about 3 - 5 microns, bacteria is around 1 - 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

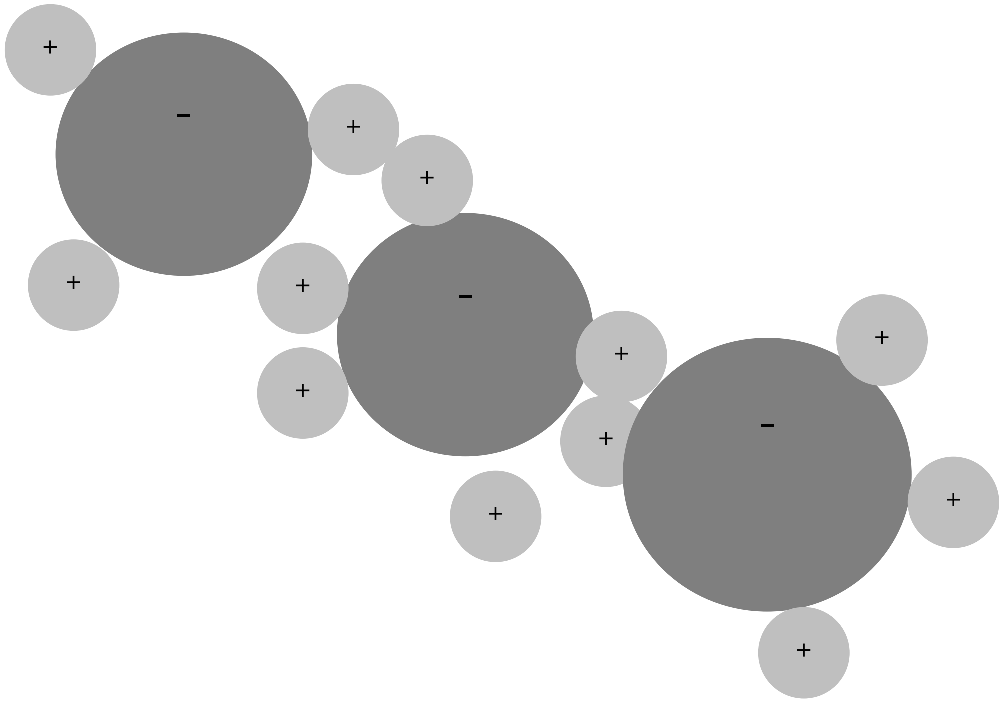
Usually, very small particles tend to attract together when they get close enough to each other, but this is not the case in pool water, where the opposite is true, i.e., the tiny particles of pollution in pool water will tend to repel, rather than attract. The cause of this repulsion is the fact that 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.



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.

Aluminium Sulphate Flakes

Polyaluminium Chloride Solution

Dosing 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 abundance of positive charge. Remember that there needs to be a balance between positive and negative to get attraction to take place. Visualise putting the positive ends of two magnets together and you will appreciate that they will not attract together any better than putting the negative ends next to each other.

These days, the recommended coagulant chemical to use in the treatment of swimming pool water is polyaluminium chloride (PAC). An alternate chemical that used to be used quite widely was aluminium sulphate (often referred to as kibbled alum, or just alum). The aluminium sulphate was supplied in solid form and typically used to get '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).

The specified dose rate for PAC in swimming pools is 0.1ml/m^3. The m^3 refers to the flow rate (a good reason to there is a flow rate meter fitted). For example, that you have a pool and the flow rate is 100m^3/hr. This means that each of those 100m^3 flowing through the system will need to have 0.1ml of PAC injected into it every hour. Another way of expressing this would be 100m^3 x 0.1ml = 10ml/hr. That's 10ml per hour (the equivalent of two teaspoons worth per hour. Now that it is known how little is required, it is easy to understand why the old method of slug-dosing aluminium sulphate (alum) is not effective. What also needs to be considered is the fact that aluminium sulphate is highly acidic, so putting large quantities of it into the skimmer baskets on poolside has negative effects, both for the swimmers and the plant system due to the corrosive conditions.

Coagulation is less effective in high rate filters than in medium rate filters.

08. Primary Disinfection

As it relates to swimming pools, the term disinfection refers to the methods used to remove the risk of infection to people who come into contact with the pool water. The methods by which disinfection is achieved in a swimming pool are a combination of physical (filtration, heat, ultra violet etc.) and chemical (chlorine, ozone etc.).

Primary Disinfection

In all pools, it is essential that the water contains sufficient concentrations of a chemical disinfectant at all times. The primary purpose of this chemical disinfectant is to act as a biocide that will kill micro-organisms (such as bacteria). If you are swimming in close proximity to another bather carrying infectious bacteria, you would want the water to have adequate biocidal properties in order to kill the bacteria as quickly as possible (within a few seconds of them being introduced into the pool water). This is the aim of maintaining a level of chemical disinfectant in the pool water as is referred to as primary disinfection.

Most of the disinfectant in common use act as effective biocides via their ability to oxidise organic compounds. Oxidation is a process whereby the organic compounds are broken down as a result of the biocide (e.g. chlorine) stripping them of electrons (the sub-atomic particles that orbit atoms).

There are two main factors that influence the effectiveness of the primary disinfection process:

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

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

When it comes to choosing a primary disinfectant, there are a number of factors a pool operator will need to consider, discussed below:

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

For the purposes of pool plant operation, chlorinated isocyanurates (also referred to as stabilised chlorine) can be thought of as a combination of cyanuric acid and chlorine. Why would a pool plant operator want cyanuric acid in addition to just chlorine? The answer is because in outdoor pools that are exposed to sunlight, the chlorine will get diminished by the UV in the sunlight. It needs an additional chemical to be added to prevent this from happening. This chemical is cyanuric acid. 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. 55% available chlorine. Comes as a white powder. pH is around 6.5.
- Trichloroisocyanuric acid. 90% available chlorine. Comes as white powder, granules or tablet. pH is around 3.0.

Dichlor and Trichlor should never be mixed. When choosing one, the main factors to consider would be the method of dosing, the pH levels and how these are going to affect the rest of the pool plant system, and the amount of available chlorine in each product.

There is a range of products in this category, with many brand names. They are white or off-white granules or tablets with a chlorine odour. Confusion with other white chemicals must be guarded against. The granules are stable when dry but will slowly liberate chlorine when in contact with water. They can explode in contact with calcium hypochlorite, ammonium salts and other nitrogenous materials and will react vigorously with strong acids, alkalis and reducing agents. Chlorinated isocyanurates should be kept well-sealed in a cool, well-ventilated place, away from combustible materials. Feeders must be designed for the particular chemical, and not used for any other.

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.

Bromochlorodimethylhydantion

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.

Bromochlorodimethylhydantion 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.

Elemental liquid bromine

This is little used in the UK. Elemental liquid bromine requires careful handling. The main risks are of spillage of either liquid bromine itself, or of bromine water. This form of bromine can cause very serious burns in contact with the skin and will produce toxic bromine gas in contact with alkaline materials. Containers should be used and stored within a bunded area, and should be handled gently, to avoid damage.

Adequate supplies of neutralising materials, such as sodium carbonate or sodium thiosulphate solutions, should be available near to hand, and there should be ready access to emergency shower facilities.

Sodium Bromide

Dosed along with hypochlorite and converts to bromine.

The recommended residual of bromine that pool operators should be aiming for is 4 – 6mg/l.

The use of bromine-based disinfectants has been linked to skin irritation (sometimes referred to as bromine itch).

Chlorine gas

We recommend against the use of chlorine gas; however, if you do choose to use it or are already using chlorine gas then there are two methods of applying chlorine gas. Both methods require a specially designed storage area for the chlorine cylinders. In the first method, the chlorine cylinders are stored in a room that is ventilated to fresh air; in the second method, the chlorine is stored in a completely sealed room. Whichever method is used, the installation must comply with Control of substances hazardous to health ACOP.

The potential for a serious toxic gas discharge is considerable where chlorine is used in its gaseous form. It is vital to ensure that the building and ancillary areas have been designed to incorporate the requirements for the safe use of chlorine.

It is important that:

- particular care is taken when changing cylinders;
- associated pipework is made of suitable material, adequately supported, and clearly labelled;
- chlorine gas cylinders should be stored only in a purpose-designed room which does not communicate with other parts of the building and which must be made secure. The room must have an exhaust system capable of dealing with minor leaks. In case of a major leak, the exhaust fan should be controllable so that the gas can be dispersed safely under controlled conditions. Minor or major leaks of chlorine gas should disperse safely without any risk to people, so storerooms should not be adjacent to public areas or close to ventilation air intakes where contamination may occur.

Where these conditions cannot be provided then the preferred system is of a totally sealed store where any gas leakage is contained. Any minor gas leakage is removed by scrubbing through a carbon filter or in the case of a major leak is dissolved by the automatic release of a fine water spray.

However, pool operators should:

- have a chlorine gas detection system installed in the store. Alarm facilities should be provided, both inside and outside the store, to warn of a chlorine leak;
- ensure employees are adequately trained in the handling and use of chlorine in cylinders;
- ensure suitable personal protective equipment (including respiratory protection) is provided;
- have a written emergency procedure, the contents of which employees are aware.

Chlorine Dioxide

This disinfectant is good at keeping biofilms under control and also has the benefit of not producing chloramines when it reacts with ammonia. On the negative side – the chorite it does produce has negative effects on health. It's not widely used in the UK, other than as a biofilm remover.

Tetra-Chloro Deca-Oxygen

Used alongside chlorine and produces chlorine dioxide. Dosed according to flow-rate in precise amounts.

Polymeric Biguanide

Inactivates, but does not oxidise bacteria, or kill algae. Incompatible with chlorine.

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 1.00 – 3.00mg/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

Much of the chemical pollution in swimming pools is in the firm of ammonia, which is a decomposition by-product of urea (which comes from sweat and urine etc. from bathers). This ammonia reacts with chlorine to form what are known as 'chloramines'. These are measured as combined chlorine by subtracting the free chlorine reading from the total chlorine reading.

Combined chlorine levels should be kept as low as possible, and certainly **no more than 50% of the free chlorine level**. In the example above, you can see that the levels of combined chlorine are within acceptable parameters.

There are four main categories of chloramines to be aware of:

- Monochloramine
- Dichloramine
- Trichloramines
- Organic Chloramines

Monochloramine is one of the chloramines which contribute to the level of combined chlorine in the water. It is produced when chlorine reacts with ammonia. In simple terms, the reaction is:

Chlorine + Ammonia > Monochloramine

Monochloramine isn't really that much of a problem, in fact, it acts as a disinfectant itself, although it is nowhere near as effective as free chlorine. Things don't stop there though and further chemical reactions will take place to produce dichloramine and trichloramine (these are the chloramines that are the cause of problems and a pool plant operator needs to know how to get rid of them and minimise their production in the first place).

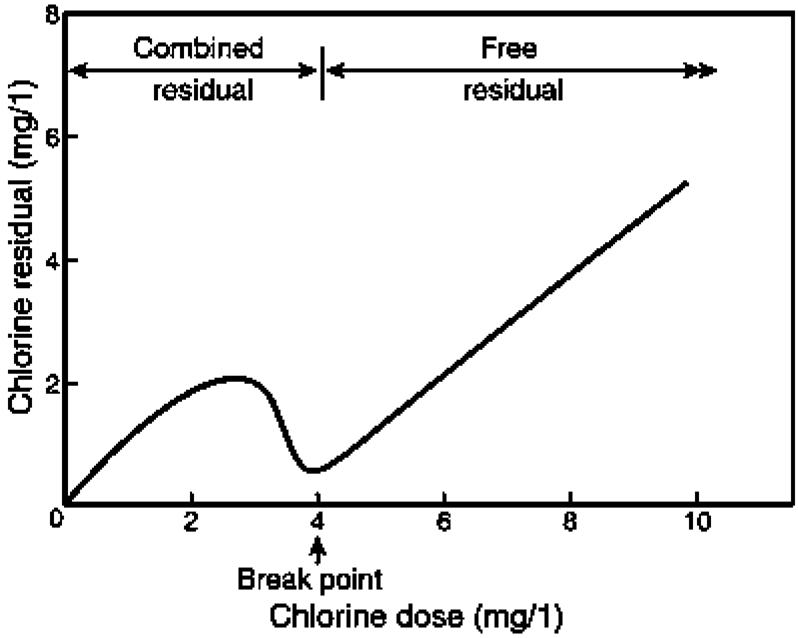
Dichloramine is one of the chloramines that contribute to combined chlorine levels in the pool water. It is the second stage of the chemical reaction that takes place between chlorine and ammonia. It is produced when chlorine (or, to be more specific; hypochlorous acid) reacts with monochloramine (which are produced during the first stage of the reaction):

Hypochlorous Acid + Monochloramine > Dichloramine

You don't want high levels of dichloramine in your pool as it can go on to form further chemical reaction by-products such as trichloramine, which we will discuss later. It's an unstable chemical though and as long as your pH is at the correct level it will break down fairly easily. At this point, your combined chlorine readings will reduce because there are no chloramines left to react with. This is known as 'breakpoint chlorination'.

Typically, in practice, you won't know how much monochloramine and dichloramine you have in your pool as normal testing procedures don't distinguish between the two. As long as you keep combined chlorine levels under control (i.e., less than half of the free chlorine), you won't really need to know, but if you start having difficulties keeping combined chlorine levels low enough, you may need to carry out a DPD2 test in order to find out which of the chloramines is contributing most to the combined chlorine levels.

Breakpoint Chlorination



In basic terms, as far as pool plant operators are concerned, breakpoint chlorination describes the point at which there is twice the amount of free chlorine than combined chlorine.

Imagine a swimming pool that has high levels of pollution. If you were to introduce some much-needed chlorine into the pool, it would quickly end up as combined chlorine as it literally combines with bacteria etc. kills it and then becomes virtually useless as a disinfectant. In fact, combined chlorine could now be classed as pollution and it is combined chlorine that makes people's eyes sting and causes irritation to nasal passages etc. Combined chlorine is something we want as little of as possible, as close to zero as we can possibly get it and certainly no more than 1.00mg/l.

As all the chlorine we have introduced has now become combined chlorine, we need to add some more. We always need to have some chlorine available (or, free) in order to quickly neutralize microbiological contamination. This is referred to as 'free chlorine'. We need the free chlorine levels to be at least double the combined chlorine levels. Free Chlorine is measured with the DPD 1 test, Total Chlorine is measured with the DPD 3 test, and Combined Chlorine is the difference between the two.

As you continue to add free chlorine into the pool, and as that free chlorine continues to convert into combined chlorine, the combined chlorine reading (the difference between the free and the total chlorine readings) will increase. Eventually though, if everything is operating properly, the chemical reactions that were discussed earlier will continue and progress even further:

Monochloramine + Dichloramine > Hydrochloric Acid + Nitrogen

The above reaction is dichloramine decomposing, and as long as this reaction continues, there will come a point where there is no more dichloramine left for the monochloramine to react with. At this point, the combined readings will start to fall, rather than continue to rise. This is referred to **as breakpoint chlorination**, which can be more easily achieved by adopting the following good practices:

- Get people into the habit of taking a shower before swimming so that there is less pollution available for the chlorine to combine with;
- Dilute the swimming pool water with enough fresh water (30 litres per bather, per day);
- Ensure enough chlorine is being dosed into the swimming pool (an automated system is always recommended for any type of commercial facility);
- Make sure that the pool turnover time is fast enough for your type of pool;
- Make sure you’re not overloading your pool.
- Keep the pH within the recommended parameters.

If you follow these steps, you should have no problem achieving breakpoint chlorination. However, if these good practices are not followed, things can start to go wrong. Instead of the dichloramine decomposing away, it starts to react with the hypochlorous acid in the pool and forms hydrochloric acid and trichloramine. The reaction looks like this:

Dichloramine + Hypochlorous Acid > Hydrochloric Acid + Trichloramine (Nitrogen Trichloride)

Trichloramine (and to a lesser extent dichloramine) are the chemicals that can cause the strong chlorine smell in badly-run swimming pools. It can also cause irritation to the mucous membranes by forming hydrochloric acid on them when they react with water. They can also trigger asthma attacks in people already suffering from asthma, but are not thought to actually cause the condition.

Organic chloramines are formed by the reaction between chlorine and organic nitrogen compounds. These are introduced into the pool at the same time as ammonia from bather urine/sweat etc. The key difference for the pool operator with organic chloramines is that they are stable and will not break down by the addition of more chlorine. In fact, the opposite is true; the levels will increase with the addition of more chlorine. Therefore, the levels must be kept under control by a process of dilution at the appropriate rate.

09. Secondary Disinfection

PWTAG recommends 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.

Secondary disinfection systems will take the form of either ozone or ultraviolet and should be designed when installed to have an effect equivalent to achieving a 99.9% reduction in the number of infective Cryptosporidium oocysts per pass through the secondary disinfection system.

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 secondary disinfectant such as chlorine will need to be added before the water recirculates back to the swimming pool.

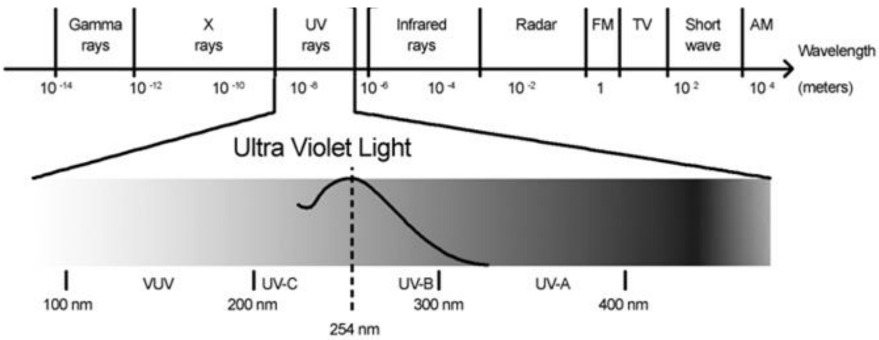
Some advantages of UV disinfection systems are that there are no chemicals to handle or store and once installed, the system does not take up too much space or require high levels of expertise to operate (unlike ozone disinfection systems). Also, it does not produce chemical by-products like chlorine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

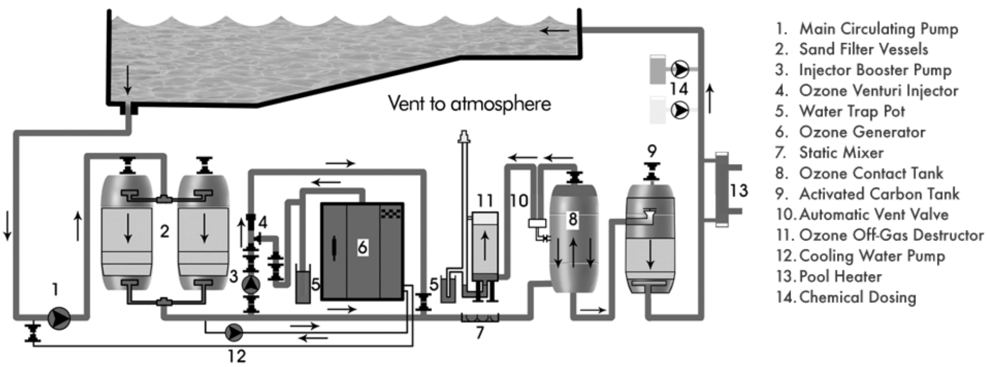
The curved black line in the diagram opposite shows the germicidal effectiveness of ultra violet light at different wavelengths.



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 secondary system, 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.

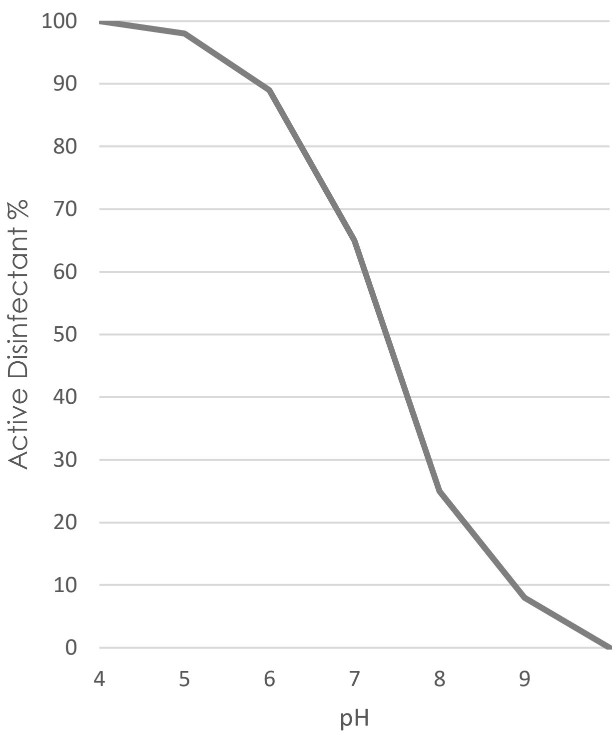


Ozone is not delivered to site, it is generated on-site. This means that there are no handling and storage issues. Ozone is a very toxic substance though and the on-site generation method means that extra training is required for pool plant operators. It is generated by passing an electrical discharge 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.

10. pH Control

pH is abbreviation for ‘power of hydrogen’ and is a critical factor in the treatment of pool water. The recommended range for the pH level to be maintained at is **7.2 - 7.6**. The reason that the pH level needs to be kept between these values is that the disinfection efficiency of chlorine falls off significantly at higher pH levels and the coagulant will also not be as effective. At lower pH values, the pool water will be too corrosive.

The effect of the pH level on the disinfection process is an area that many pool plant operators fail to fully understand. Therefore, they don't take the correct actions and end up with low quality swimming pool water and an excessive yearly spend on chlorine. Let's take a look at what's going on with pH and chlorine.



The trend line in the graph represents the percentage of active disinfectant in the chlorine and as you can see, the percentage of is dependent on the pH level. When you add chlorine to the swimming pool water, chemical reactions start to occur. The chlorine reacts with the water and ends up producing the following two substances:

1) hypochlorous acid
2) hypochlorite ion

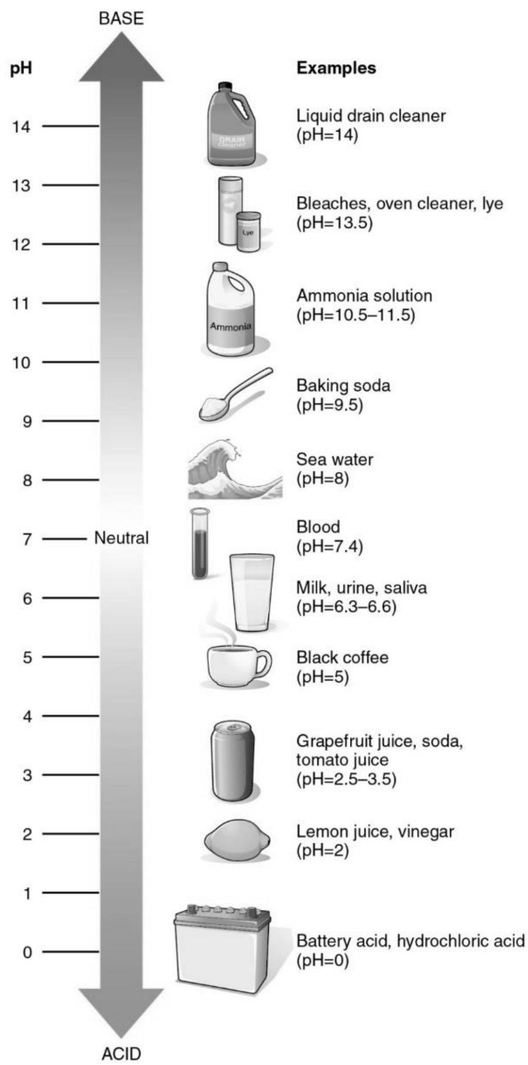
The key disinfectant in chlorine is hypochlorous acid, which is about x100 stronger than the hypochlorite ion, so that's what we want more of.

The higher the pH level, the higher the proportion of hypochlorite, the lower the pH level, the higher the proportion of hypochlorous acid.

At a pH level of 7.5, you've got about 45% of the chlorine as hypochlorous acid, so if your free chlorine reading was 1.0 mg/l when tested, in real terms the amount of active disinfectant would only be around 0.45mg/l. If the pH level was allowed to get to 8.0, then only 25% of the chlorine would be hypochlorous acid, so if the test reading came out at 1.0 mg/l again, the actual amount of active disinfectant would only be 0.25mg/l, which would be too low for adequate disinfection.

You need to bear in mind that the free chlorine reading includes both the hypochlorous acid and the hypochlorite, but it does not tell you the proportion of each. This is why it's so important for pool plant operators to understand how and why the pH levels have such a dramatic effect on the disinfection process.

Because both calcium hypochlorite and sodium hypochlorite (the most commonly used chlorine disinfectants) are very high on the pH scale, the pH of the pool water will be pushed when these disinfectants are dosed into the pool. As explained above, this would mean that the effectiveness of the disinfectant would be reduced. What needs to happen is a chemical needs to be dosed that is low on the pH scale (i.e., an acid). Some chemicals that are commonly used for this purpose are:



- Carbon Dioxide
- Sodium Bisulphate (dry acid)
- Hydrochloric Acid
- Sulphuric Acid

These chemicals serve no other purpose than to bring the pH level back down to between 7.2 – 7.6. They make the disinfectant far more effective, but they do not act as disinfectants directly.

Carbon Dioxide

CO2 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 CO2 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 CO2 leave the body and so there is less room for oxygen (O2). Without sufficient O2 one cannot live. This effect is called intoxication.

CO2 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 CO2 with sodium or calcium hypochlorite (in liquid form) through spillage in bunds or operator error when acids are mixed in day or main tanks with hypochlorite. This means no possibility of accidental production of chlorine gas – a significant hazard in swimming pool installations.

Sodium Bisulphate

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.

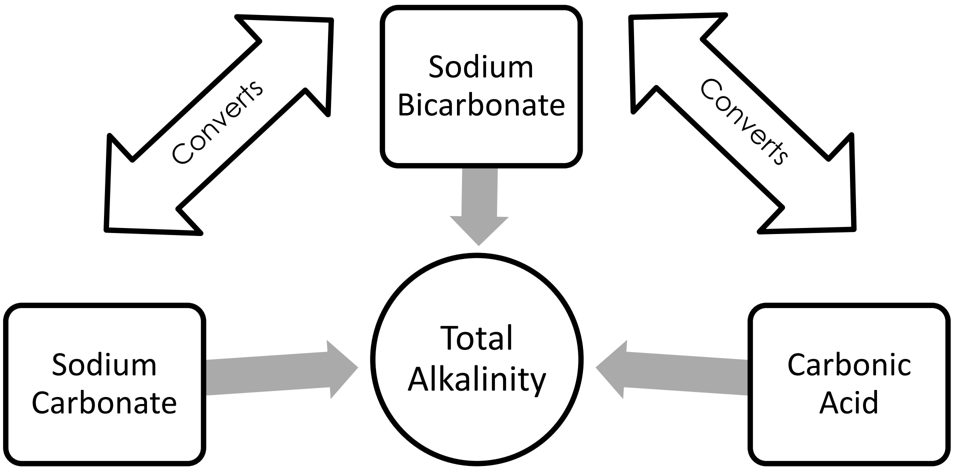
pH Bounce, pH Lock and Total Alkalinity

The pH scale is logarithmic, which means that something with a pH value of 6.9 is ten times more acidic than something with a pH value of 7.0. Something that is pH 6.8 is ten times greater than 6.9. Something that is 6.7 is ten times greater than 6.8 and so on. Therefore, pH 6.0 is a million times more acidic that 7.0. These are obviously big differences, even if they don't appear that way on paper. Because of the logarithmic nature of the pH scale, most pool operators will tend to find that when they test the pH of the pool water using a phenol red tablet, the results tend to remain fairly consistent over time. The automatic chemical dosing system will be continually monitoring the pH level and dosing in some acid when it detects pH levels going too high. When it detects pH levels are going too low, it will shut off the acid dosing.

Problems controlling the pH level do sometimes occur though. Either the pH level won't budge no matter what you do to try and change it (pH lock), or the pH level fluctuates all over the place from high, to low and then back high again (pH bounce). Both of these problems are being caused by your total alkalinity levels being either too high (which causes pH lock) or too low (which causes pH bounce). Total alkalinity refers to the total amount of sodium carbonate, sodium bicarbonate and carbonic acid that are in the pool water. Collectively, these three chemicals are referred to as total alkalinity. If you find that the total alkalinity levels are low, you're going to need to add some sodium bicarbonate. This chemical will introduce some alkalinity into your pool without having too much of an effect on the pH level. The sodium bicarbonate that you add will go through various chemical reactions and some of it will convert into different chemicals according to what the pH level is at any given time. If the pH is high, some of the sodium bicarbonate will convert to sodium carbonate. If the pH is low, then some of the sodium bicarbonate will convert to carbonic acid.

So, when we're dealing with total alkalinity levels and its relationship with pH, we're actually dealing with three chemicals, not one, because a proportion of the chemical you add to alter the total alkalinity (sodium bicarbonate) will change into either sodium carbonate or carbonic acid, depending on what the pH level is.

This chemical reaction is important for pool plant operators because it is this process that has the stabilising/buffering effect on the pool water's pH level. Without this chemical reaction going on, the pH levels would be very difficult to control and would either be swinging from low to high and back again (pH bounce), or won't budge at all (pH lock). What's happening is that hydrogen ions are either being released, which will cause pH levels to come down (because hydrogen ions are acidic), or they are being mopped up, which will cause the pH levels to rise.



pH Low	pH High
At low pH levels, some of the sodium bicarbonate will convert into sodium carbonate, which ‘mops up’ acidic hydrogen ions. The removal of this acidity has a ‘buffering’ effect on decreasing pH levels.	At high pH levels, some of the sodium bicarbonate will convert into carbonic acid, which releases acidic hydrogen ions. This acidity has a ‘buffering’ effect on increasing pH levels.

Let's look at a practical example to make some sense of this:

Situation: pH is high, so you add some acid to bring it down. But then it goes down too low, turn off acid dosing to try and bring the pH up again. But then it ends up going too high again.

Cause: The pool water is not 'buffered'. This is because the pool water does not contain enough total alkalinity. Without enough total alkalinity, the release, or mopping up process described above is not happening. If there was enough total alkalinity, the pool water would be buffered and what would have happened when you added the acid in order to get the pH down is the sodium carbonate would have 'mopped up' some of the acidic hydrogen ions as it went through the chemical reaction process described above.

Solution: Get that pool water buffered! Think of un-buffered pool water as being an extremely reactive substance. Get some sodium bicarbonate in there in order to calm things down and give you some control back. If you get the total alkalinity levels back into the correct range (80 – 120mg/l if using calcium hypochlorite, 120 – 150mg/l if using sodium hypochlorite), you will find that the pH levels aren't as reactive and are therefore much easier to control. Unless you buffer the pool water, you'll be in and out of the plant room all day long!

A test for the levels of total alkalinity should be carried as part of a series of weekly tests on the pool water to determine whether it is corrosive, scale forming or balanced (these tests are called the langelier saturation index). See below for recommended parameters and what to do to correct them if they fall outside of them:

- When using calcium hypochlorite the recommended range is 80 – 120mg/l
- When using sodium hypochlorite the recommended range is 120 – 150mg/l
- If the levels go too high, dilute with fresh water.
- If the levels go too low, add some sodium bicarbonate.

The quantity of sodium bicarbonate you need to add to increase the level of total alkalinity by 20mg/l is 1.7kg per 50m^3 of pool water volume (if you wanted to increase the total alkalinity by 40mg/l, you would need to double these figures). See below for a few examples:

- For a pool volume of 50m3 — 50 / 50 x 1.7 = 1.7kg
- For a pool volume of 100m3 — 100 / 50 x 1.7 = 3.4kg
- For a pool volume of 275m3 — 275 / 50 x 1.7 = 9.35kg
- For a pool volume of 350m3 — 350 / 50 x 1.7 = 11.9kg

To get the sodium bicarbonate in the pool, make up a solution by dissolving the sodium bicarbonate in water and then distribute it as widely as possible over the surface of the pool.

11. Chemical Dosing

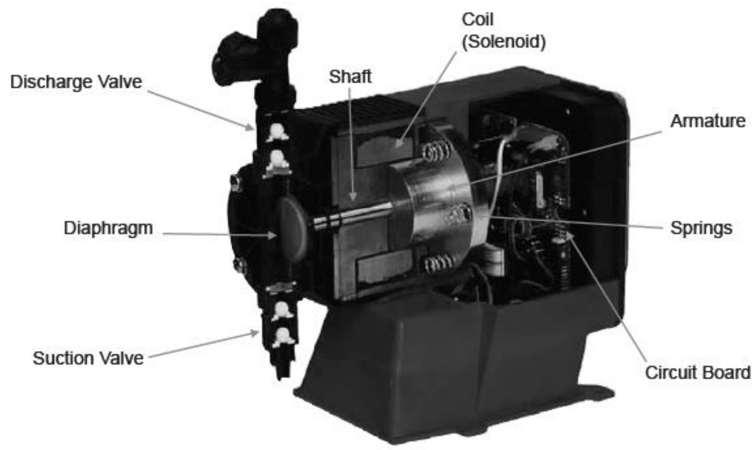
A pool operator is advised to make a realistic assessment of the type of swimming pool they are operating – domestic, or commercial? This book and the course is aimed at commercial swimming pools and spas, not domestic. Some factors to consider when making this assessment are:

- Size of pool
- Bathing loads
- Setting (school, leisure centre, hotel, etc.)
- Hours of operation

If the pool is a commercial facility, then it needs to be operated as such. Far too many operators are running commercial pools using practices more appropriate to a domestic pool. This can lead to major inadequacies in arrangements.

Automatic Dosing

Automatic monitoring and dosing of water treatment chemicals should be the norm in a commercial swimming pool/ spa. Hand-dosing chemicals should only be undertaken in exceptional circumstances, after a thorough and robust risk assessment has been conducted, and only by people trained and competent to do so. Chemical dosing should be continuous, 24 hours a day. The automatic dosing system should be backed up by regular monitoring and verification.



Usual practice is to dose disinfectant prior to filtration. This is achieved by injecting a solution into the circulation pipework by means of a chemical dosing pump. A common type of pump used for this purpose is a diaphragm pump, which uses a rubber disc (the diaphragm) to create suction in the chemical feed line when it moves backwards, and then creates a pressure in the feed line on the discharge side when it moves forwards. Dosing disinfectant before the filter(s) prevents inadvertent mixing of disinfectants and acids (which should be added post-filter). With ozone and ultraviolet systems (which removes residual disinfectant), dosing is always after the ozone or UV treatment.

The pH correctant (in the UK, usually acid-based), is usually dosed after filtration, in a similar manner to that described above for disinfectant dosing.

Chemical Pumps

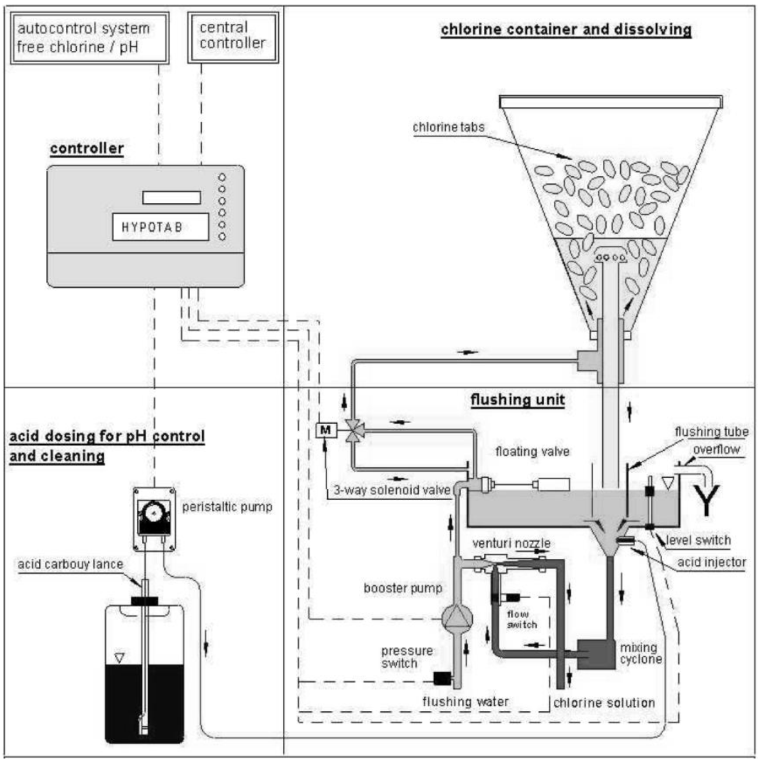
Chemical pumps need to be appropriately specified. Under-specified pumps will not be able to cope demand and will under-dose, conversely, over-specified pumps may end up over-dosing chemicals.

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.

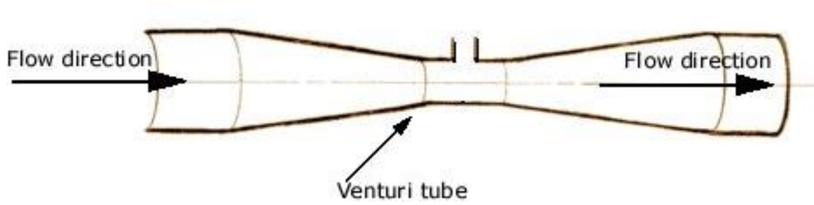
For illustrative purposes, if the amount of pollution being introduced into the pool is such that 1.00 mg/l of free chlorine would only last an hour, then the pump would need to be capable of pumping the quantities detailed above every hour. Of course, if the pollution levels are kept under good control,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

An alternative dosing system to that described above is a specially designed unit that is capable of dosing both disinfectant and acid (and sometimes coagulant too) from the same system (though not at the same time.



These systems make use of a venturi valve, which uses suction, rather than pressure to draw the chemical solution into the system.



A peristaltic pump is used for the acid dosing in these types of system. This involves pushing the chemical solution through a flexible tube by using a rotating constriction device. These types of pumps are also used for the dosing of coagulants, since they are effective at dosing low volumes of solution.

Whatever the system used, all chemical pipework, suction lines, delivery lines and tanks should be marked to identify the contents. Pipes should also be labelled with the direction of flow. All pipes used for pumping chemicals should be double sheathed.

Precaution cards and first aid instructions should be displayed for each chemical. CAS and EINECS numbers should be included on the precaution cards so that in the event of an accident emergency services will know what the correct medical treatment is.

Pipework, Valves, Fittings

Pipework needs to be made of material that is resistant to the chemicals that will be pumped through it. It also needs to be capable of withstanding the maximum pressure able to be generated by the chemical pump. Pressure relief valves should be fitted.

Pipework should be sited so as not to give rise to danger (leaking chemicals, slips, trips etc.) and be protected against damage. Protective sleeves should be fitted to prevent chemicals being dispersed and spread in the event of a rupture of the pipework.

Disinfection injection points should be sited away from pH correctant injection points (at least 1 metre, but the further, the better). This is to prevent the incompatible chemicals form mixing together in the pipework. They should also be sited such that the injected chemicals mixes well with the pool water. This can be done by injection before bends/junctions etc. where the movement of water through that section will help the mixing process.

Carbon Dioxide (CO_2) Installations

Many facilities opt for CO_2 dosing systems rather than mineral acid systems. This involves storing CO_2 in a high-pressure liquid state in cylinders. Larger facilities make use of a bulk storage system, with deliveries being made from a tanker that connects to an external filler point. If cylinders are used, there will be a risk form manual handling when changing over from an empty cylinder to a full one, so a risk assessment and appropriate control will be a requirement.

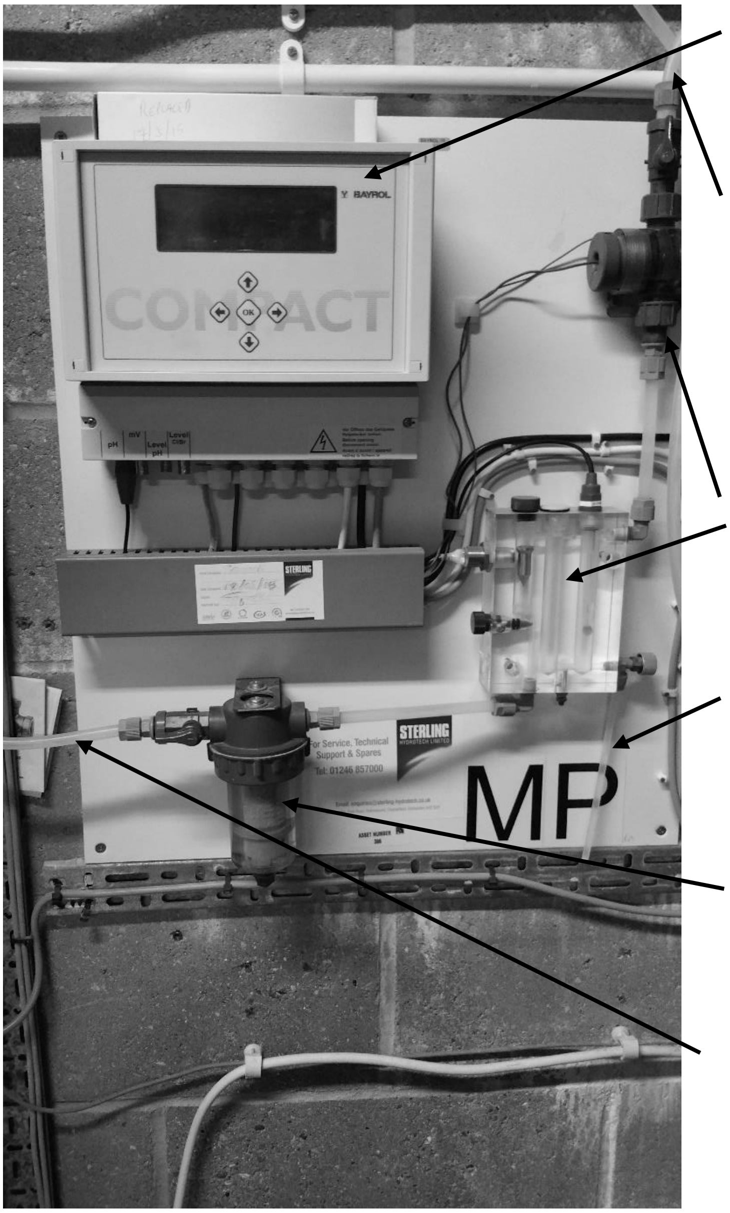
The liquid CO_2 changes to a gas phase when passed through a pressure reducing valve and is injected into the circulation pipework where it dissolved into the pool water and forms carbonic acid and thus reduces the pH value of the water.

The use of CO_2 might well be safer for pool staff because of the reduced handling of chemicals and virtually no risk of accidental mixing of disinfectant and acids. The chemicals is an asphyxiant though, so measure need to be taken to ventilate the area and alert staff to hazardous levels of CO_2 gas in the environment.

Monitoring

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 swimming pool chlorine and pH levels.

A typical automatic dosing system will comprise of an electronic control unit connected to probes that are being supplied with a representative sample of pool water via a feed line taken from the circulation pipework. These probes are constantly monitoring the levels of free chlorine and pH, and are electrically interlocked to pumps that turn on or off according to the readings from the probes and the parameters that have been pre-programmed into the control unit. See below for a labelled image of a typical control unit.



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:

Operation, 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 of time (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 the nature and operation of the system.

Fail-Safe Systems

In all disinfecting systems which incorporate automatic chemical dosing (including those using chlorine, unless the chlorine injection system is negative pressure and the chlorine gas line has a vacuum-operated regulator), the following precautions should be considered as appropriate:

- interlocking the dosing system electrically with the water circulating pumps, to prevent the continuation of dosing, should the pumps fail
- incorporating into the circulation system a fail-safe, flow measuring device capable of detecting a reduction or cessation of flow and interlocking this with the dosing pumps to prevent continuation of dosing
- siting the pool water circulation pumps below the level of the pool water, to minimise the risk of the pumps losing their prime
- locating an additional sampling point close to the chemical injection point for alarm purposes. (Automatic dosing systems operate by sampling the water and activating or stopping the dosing pumps as required, for example following a change in bather loads.) Disinfectant dosing should cut off when the system fails
- 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)
- designing dosing lines so that they are protected from damage, and so that they cannot, inadvertently, be connected the wrong way round
- displaying notices warning of the risks of mixing calcium/sodium hypochlorite and acids, and the importance of maintaining pool water circulation during dosing
- ensuring that pressurised chemicals in the line are safely relieved before breaking the delivery line for maintenance work to be carried out

Pipelines and injection points can become blocked by calcium deposit. 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.

Constant-Rate Dosing

Circulation feeders

Circulation feeders are items of equipment that take dry chemicals and introduce them into the pool. They are mainly used for disinfectants, though they have some use in dosing pH chemicals. There are two types:

- erosion feeders are designed so that water flowing through them physically erodes material from a dry tablet; this subsequently dissolves in the water circulation. Calcium hypochlorite and trichlorinator feeders can be of this type
- soaker feeders allow water to dissolve material from the tablet directly. Brominators are of this type

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. 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.

Trichlorinated isocyanurate tablets should be kept completely submerged and should be fully used up prior to extended periods of circulation shut down.

Circulation feeders should not be sited near a heat source, nor installed such that they are subjected to a heating effect.

The system design should take into account the possible sources of the hazards, which systems are important for safety, and the associated safety integrity of those systems. From this the reliability and quality of equipment can be obtained and an appropriate equipment configuration designed. This should be undertaken by those with appropriate knowledge and expertise in this area.

To prevent system failure, the equipment needs to be maintained to ensure it is functioning correctly and that its condition is not deteriorating. This can be achieved by regular testing of all warning and safety devices, the interlocks, and inspection of the equipment by a competent person. The required frequency of this testing depends on the system design and on the particular equipment installed. The manufacturer's advice should be followed. In the absence of this, all safety interlocks should be tested at three-monthly intervals.

Chemical dosing operations

Written procedures should be established for day tank filling, mixing or diluting chemicals and cleaning injectors. There should also be built-in safeguards to cover those periods when the plant is not attended.

If the plant is to be shut down for longer than 60 hours, valves infilling 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 dosers should be interlinked with the circulation pumps and the circulation of water through the system, so that dosing stops if there is pump failure.

Day 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 form header tank
- Drain valve
- Agitator

Preparing dosing chemicals

- Chemicals should always be added to water and never the other way round 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.

Manual Dosing

Sometimes there will arise a need to introduce chemicals into the pool manually (hand-dosing). This is a potential hazardous activity and should not be performed by people who have not received the appropriate level of training.

General Procedures

- 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 are advised to be used for hand-dosing of pH correctant are sodium bisulphate powder (dry acid) in order to reduce the pH value and sodium carbonate in order to increase the pH value. 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 value of the pool water due to the pH buffering effect of the total alkalinity levels of the pool water. 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.

Whatever pH correctant is being hand-dosed, refer to the manufacturer's instructions, which should be on the label on the side of the chemical container. Bear in mind that the recommended amounts may need to adjusted, based on your own experience.

Increasing or Decreasing Calcium Hardness

You need to try and keep your calcium hardness levels between 75 – 150mg/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. In order to calculate how much you need to add, we recommend working on the basis that 1mg/l of calcium hardness is equivalent to 1g/m^3 of pool volume. See the worked example below to increase calcium hardness by 1mg/l in a 300m^3 pool:

$$300m^3 \text{ X } 1g/m^3 = 300g$$

If you needed to increase the calcium hardness by 50mg/l, you would simply multiply 300g by 50, so you would be adding 15,000g (or 15kg).

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). Use the same calculations as above for calculating how much to add (1g for every m^3 of pool volume to increase total alkalinity readings by 1mg/l).

12. Pool Water Testing

This chapter will outline how to carry out the range of tests that are required, including:

- free chlorine
- total chlorine
- pH
- calcium hardness
- total alkalinity

The chapter covers the use of comparators and photometers, but does not cover test strips as these are not recommended for testing commercial facilities (they are more suited to domestic pools).

Documentation

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.

Reagents

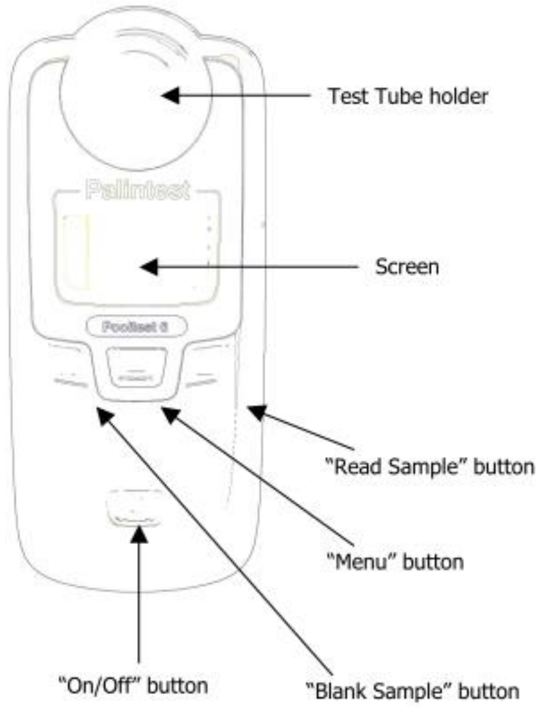
Pool water testing works by adding reagents to a sample of pool water and interpreting the results according to the colour of the sample once the reagent has had time to react with it. Different tests require different types of reagents. The type of testing equipment (comparator or photometer) will also influence the type of reagent that needs to be used. Also, with some tests (total alkalinity, calcium hardness, cyanuric acid), the reagents have slightly different names and product codes, depending on which supplier you use. If you have a photometer, look to see who the manufacturer is and contact them direct to order your pool test reagents. Explain to them what tests you need to carry out and whether you are using a photometer, comparator and/or shaker bottle method (for total alkalinity and calcium hardness) and they will be able to ensure you are using the correct reagent for the job. They will store your ordering information on your account and this can save a lot of time and confusion when it comes to ordering fresh supplies.

Comparators

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

Photometers

These are devices that work electronically. A test tube containing a sample of pool water is placed in the device, which shines light through the sample. A reading is taken and the result is displayed on the device's screen.

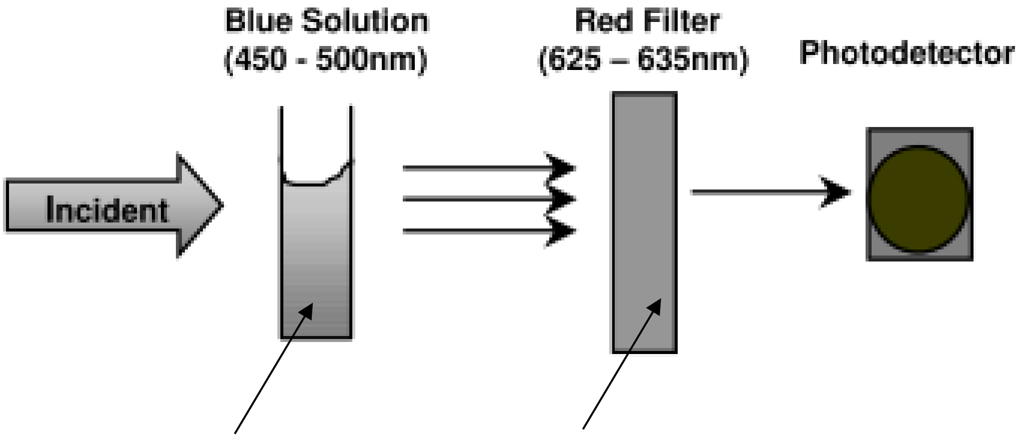


Palintest tests are based on measuring the intensity of colours produced by Palintest reagents and using Palintest photometers to measure that intensity of colour. This is colorimetry and can be defined as any technique used to evaluate an unknown colour in reference to known colours.

To avoid subjective measurement between test samples and colour standards, a colorimeter can be used for quantitative measurement of the amount of coloured light absorbed by a sample (with reagents added) in reference to an untreated sample (blank).

White light is made up of many different wavelengths of light. A colorimeter passes a white light beam through an optical filter which transmits only one particular band of wavelength of light to the photodetector where it is measured. The difference in the amount of coloured light transmitted by a colourless sample (blank) and the amount of coloured light transmitted by a coloured sample is a measurement of the amount of coloured light absorbed by the sample.

The use of filters improves the sensitivity of this process and choice of the correct optical filter (and, therefore, the correct wavelength) of light is important. It is interesting to note that the filter that gives the most sensitive calibration for a test factor is the complementary colour of the test sample. For example, the chlorine test produces a pink colour proportional to the chlorine concentration in the sample (the greater the chlorine concentration, the darker the pink colour). In this case, a green filter gives the greatest sensitivity as a pinkish-red solution absorbs mostly green light. Palintest photometers calculate and then display the test results directly in milligrams per litre (mg/l) of the test factor, by comparing the amount of absorbed light to the calibration data programmed into the instrument.



Wavelengths of blue light plus small quantities of red light pass through the solution.

Red light only passes through the filter. All other light is absorbed.

Blanks and Samples

Palintest photometers use a BLANK tube to set the instrument to blank and a SAMPLE tube to take the reading. A BLANK tube is a test tube filled with an untreated water sample. A SAMPLE tube is a test tube containing the sample to which reagents have been added in accordance with the test procedure described.

The blank setting is held in memory. It is not necessary to reset the blank each time a reading is taken if the water samples to be tested are from the same body of water and the conditions of use are the same. The blank setting can be confirmed if necessary by taking a test reading on the blank tube.

Taking a Reading

1. Press the 'on/off' button to start the unit.

2. Press the 'menu' button until the test you wish to perform is indicated on the screen.

3. Insert your blank tube and press the 'blank sample' button.

4. An image displaying a blank tube will be displayed on screen. When this is replaced by 0.00 the instrument is finished blanking and ready to take a reading.

5. Remove your blank tube and replace it with the sample tube. Press the 'Read Sample' button to take a reading.

6. The result will be displayed on screen in mg/l.

Care and Maintenance

The handling of photometer tubes is important to ensure continuing accuracy. Scratches, finger-prints and water droplets on the tube or inside the light chamber can cause inaccurate results. It is imperative that the tubes and light chamber are clean and dry

The glassware must be clean and defect-free. Scratches and abrasions will permanently affect the accuracy of the readings. Tubes can be acid washed periodically.

Here are some hints on keeping the photometer clean, free from contamination and in good working order:

1. Prepare your workplace before use. Make sure that you have enough space to work with the photometer and with the reagent systems.

2. Do not pour out samples or prepare the tests directly over the instrument.

3. Always cap the test tubes after preparing the blank and test sample.

4. Wipe test tubes on a clean tissue to remove drips or condensation before placing in the photometer.

5. Do not leave tubes standing in the photometer test Chamber. Remove the tubes immediately after each test.

6. Immediately wipe up any drips or spillages onto the Instrument or into the test chamber with a clean tissue.

7. Keep the instrument clean. Clean the test chamber regularly using a moistened tissue or cotton bud.

8. Keep the instrument in a clean, dry place when it is not in use. Keep it on a clean, dry bench away from Chemicals, place it in a storage cupboard or keep it in a carrying case.

Viewing the Instrument Memory

To view the previous results (10 results are stored within the instrument memory), hold the 'menu' button whilst the display showing the selected test or result is on the screen.

Backlight Operation

The backlight can be turned on and off by holding the 'On/Off' button for a two second period during power on.

The methodologies listed here are for use with the Pooltest 3 and Pooltest 6 instruments. Before attempting to do any tests, ensure you read 'Blanks and Samples' and the 'Care and Maintenance 'sections.

There are many different models of photometer available and if you don't want to waste money, it is important to make sure that you buy the correct model for your needs. There are many facilities that have spent a lot of money on the purchase of a photometer that is capable of carrying 25 different pool tests, including things like copper, iron, manganese etc. An example of this type of photometer is shown on the left below. For most pools a photometer like the one shown to the right below is sufficient. It's supplied by Palintest and is called the Pooltest 6 (because it can carry out 6 different types of test; Chlorine, pH, Cyanuric Acid, Total Alkalinity, Calcium Hardness, Bromine). For the majority of pools, this is more than enough, so there is really no need to go and purchase the much more expensive Palintest 25.

Pooltest 25 Professional Plus

Pooltest 6

Collecting Samples

Pool water samples should be collected as far as possible away from the inlets. This is because the water returning to the pool from the plant room will have recently been injected with a fresh dose of disinfectant. Therefore, the water coming into the pool at the inlets will be relatively strong with disinfectant, while the water at the furthest point from the inlets will be relatively weak with disinfectant. If you are getting satisfactory readings at the furthest point from the inlets (where the disinfectant is weakest), it stands to reason that you must have a satisfactory reading throughout the pool. If you took the sample from too close to the inlets, you may be led to believe that the disinfectant levels were satisfactory, but there is actually a chance that the disinfectant levels could deplete to below the recommended parameter by the time it got to the outlets.

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'. If you find that your disinfectant readings are satisfactory from within the most heavily polluted area of the pool, you can be reasonably confident that disinfectant levels will be satisfactory everywhere.

General Points on Pool Water Testing

- the equipment used should be clean and dry
- reagent tablets should not be touched as this would affect the reading
- COSHH assessments should be carried out on all reagent chemicals
- all samples should be taken from the same, pre-determined point every time
- staff should be trained in pool water testing
- pool testing and effective lifeguarding cannot be carried out at the same time
- photometers should be re-calibrated on an annual basis
- if results are not as expected, always do an immediate re-test
- put test tubes on a stable, flat surface when crushing the reagent tablets

Free Chlorine Test

1. Rinse out two test tubes with pool water.

2. Fill one up to the 10ml mark, leave the other empty but damp.

3. Put a DPD 1 tablet into the empty tube, without touching the tablet.

4. Watch the reaction of the tablet. If you can see any pink colour – there is chlorine.

5. Fill the test tube with the DPD 1 tablet to the 10ml mark.

6. Crush the tablet with the crushing rod. Ensure the tablet is completely dissolved and there are no bubbles left in the test tube before continuing.

7. If the water is no longer pink – you have too much chlorine and it has bleached the colour out of the sample. Do a retest to confirm.

8. Obtain a reading according to the type of tester you are using (comparator or photometer). See below:

For Comparator

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

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

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

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

13. Record the reading on the pool test sheet.

For Photometer

9. Put the 'blank' test tube into the slot on the photometer.

10. Put the light cap (if there is one) over the test tube*.

11. Turn the photometer on and select the free chlorine mode.

12. You will be prompted to 'zero' the photometer.

13. Swap the blank with the test tube with the DPD 1 tablet.

14. Remember to replace the light cap.

15. You will be prompted to press the test button.

16. Record the reading on the pool test sheet.

* Photometers work by shining a light through the sample. All external light needs to 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 so that it stops light entering the sample.

Total Chlorine Test

1. Add a DPD 3 tablet to the test tube that already contains the DPD 1 tablet.

2. Crush the tablet with the crushing rod.

3. Wait for 2 minutes

4. Take the reading in the same way as for the DPD 1 test.

5. Record the reading on the pool test sheet.

Depending on the model of photometer you are using, you may have to press the 'mode' button in order to ensure that the device is set up for reading total chlorine (rather than free chlorine). Also, some photometers have a built in timer that counts the two minutes down automatically.

Calculating the Combined Chlorine Reading

The combined chlorine is worked out by simply taking the free chlorine result away from the total chlorine result:

Total Chlorine - Free Chlorine = Combined Chlorine

pH Test

1. Rinse out another test tube with pool water (use the same 'blank' that was used with the chlorine tests).

2. Fill the test tube up to the 10ml mark.

3. Put a Phenol Red tablet into the sample, without touching the tablet.

4. Crush the tablet with the crushing rod. Ensure the tablet is completely dissolved and there are no bubbles left in the test tube before continuing.

5. Obtain a reading according to the type of tester you are using (comparator or photometer). See below:

For Comparator

6. Put 'blank' test tube in the left slot and the test tube with the Phenol Red tablet into the right slot.

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

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

For Photometer

9. Put the 'blank' test tube into the slot on the photometer.

10. Put the light cap (if there is one) over the test tube*.

11. Turn the photometer on and select the pH mode.

12. You will be prompted to 'zero' the photometer.

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

10. Record the reading on the pool test sheet.

13. Swap the blank with the test tube with the Phenol Red tablet.

14. Remember to replace the light cap.

15. You will be prompted to press the test button.

16. Record the reading on the pool test sheet.

Calcium Hardness and Total Alkalinity Tests

We recommend learning the shaker-bottle method of testing for calcium hardness and total alkalinity as the tests are easy to preform and do not rely on the availability of special equipment other than a shaker bottle and the test tablets. 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

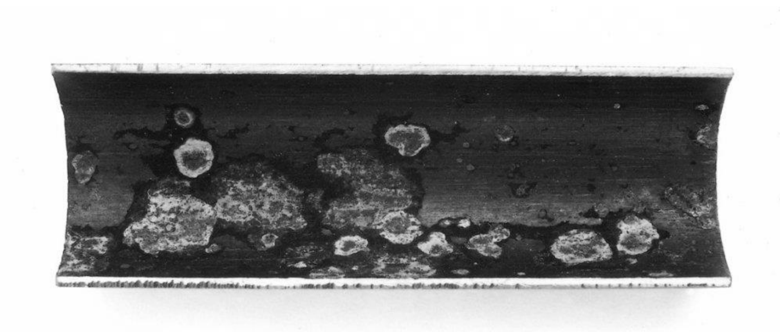
Balanced water testing is something that swimming pools should be doing weekly in order to determine whether pool water is 'balanced'. This refers to whether the water is corrosive or scale-forming, or neither (balanced).

Corrosive water is contains little calcium (soft water) and is therefore ‘hungry’ for that substance. It will eat away at anything that contains the calcium it needs. Tile grout is usually high in calcium and is therefore very vulnerable to attack from corrosive water.

Scale-forming water does the opposite of corrosive water and instead of eating away at things it will deposit a scale on them (you're likely to have seen the effect of this on the heating element of your kettle if you live in a hard water area). It does this because it contains high amounts of calcium (hard water) and will readily give up this excess calcium onto the various surfaces it comes into contact with. This scale-forming can be a problem if it is allowed to build up on the inside of pool circulation pipework etc. where it will affect pipe diameters and flow rates. It also looks unsightly, especially on darker surfaces.

The aim of good water balance management is to have water that is neither corrosive, nor scale-forming (i.e., balanced). The main factor that drives the need for good water balance is planned preventative maintenance (PPM). This is different to the tests for chlorine and pH levels, where the main factor is bather safety and reducing the risk of cross-contamination. Therefore, the water balance test results are lower priority than the chlorine and pH test results. This does not mean that the water balance tests should be neglected though because if they are, the result could be many thousands of pounds worth of remedial maintenance repairs and replacement parts further down the line.

Scale formation in pipework



Corrosion in pipework

Step 1.

Carry out tests (testing methods are explained in water testing chapter) and note results for:

- 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.

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

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

The ideal result is somewhere between 0.1 - 0.4. 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:

- Take a 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.

13. Other Types of Pools

Spa Pools

A spa pool is designed for sitting or lying in up to the neck, and not for swimming. It is a self-contained body of water that is filtered and chemically disinfected. A spa pool 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 30°C to 40°C, and have hydrotherapy jet circulation with or without air induction bubbles.

Spa pools can be sited in or outdoors. Common terms for spa pools are hot spa, hot tub, whirlpool spa and portable spa. Jacuzzi® is the registered trade name of a specific manufacturer and should not be mistaken for a generic name for spa pools.

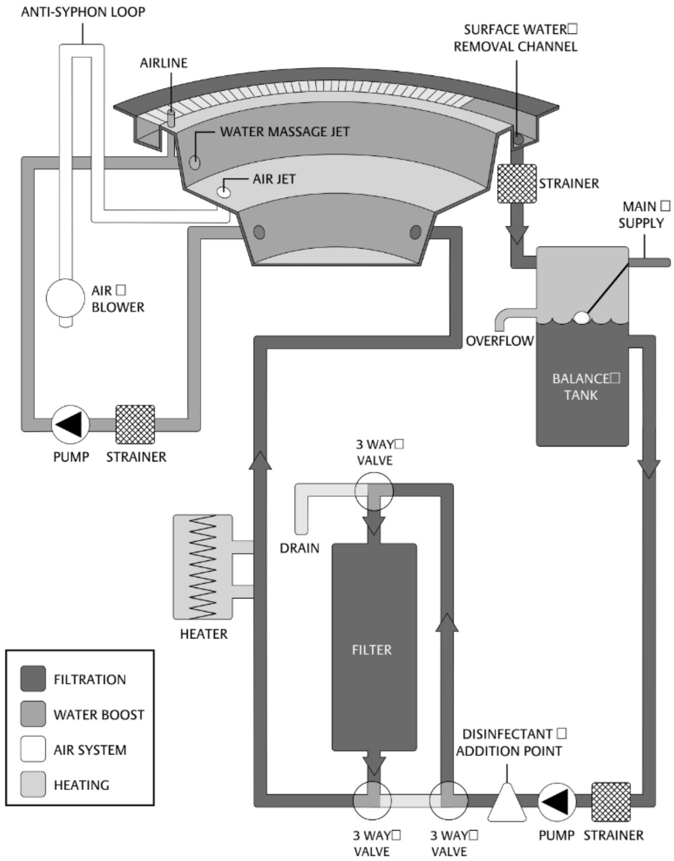
A commercial spa pool is an overflow/level deck spa pool installed in a commercial establishment or public building, and generally used by people visiting the premises. Typical sites for commercial spa pools include hotels, health clubs, beauty salons, gymnasia, sports centres and clubs, swimming pool complexes, and holiday camps. A spa pool in such a location is considered commercial even if payment for use is not required. A domestic spa pool installed in a hotel bedroom or holiday home should also be managed as a commercial spa pool. Similarly spa pools rented out to domestic dwellings for parties etc. must also be considered commercial.

Design bathing loads

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 ten times the capacity of water in the spa pool system when measured in cubic metres. Practical experience with a particular spa pool and a full risk assessment are needed to confirm that this bather load gives satisfactory water quality.

Circulation

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.



With effective skimming and filtration systems, there should be a maximum water turnover time of 15 minutes for domestic spa pools, and a 6-minute turnover time 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.

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.

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.

Spa operators should be mindful of the risk of entrapment/entanglement at the outlets (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).

Air blower system

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.

Filtration

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. Filters should always be backwashed before the pressure rises above normal clean operating pressure by 0.35 bar (5lbs/in2). Diatomaceous earth filters should be backwashed and recharged according to manufacturer's instructions.

Dilution

For stand-alone commercial spa pools the SPATA standards recommend that the spa pool water should be replaced with fresh water when:

- The number of bathers = 100 x the water capacity measured in m3;

  or

- The number of bathers = half the water capacity measured in gallons.

In heavy use commercial situations stand-alone spa pools are likely to need draining and water replacement at the end of each day.

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.

Disinfection

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 accumulation of organic matter in the strainers, filters and pipework etc.

Monitoring

Poolside testing and recording of residual disinfectant and pH levels should be undertaken before the spa pool is used each day and thereafter at least every 2 hours in commercial spa pools. The chemical tests required are:

- Colour
- Clarity
- Temperature
- Number of bathers
- Chlorine (free, total and combined) or bromine in pool
- pH
- Total dissolved solids (TDS)

A logbook should be available for recording the results, it should state the acceptable limits for parameters tested, together with any remedial action to be taken in the event of a test result being out of specification. Records should be kept for a minimum of 5 years as required by the Approved Code of Practice L8.

The total dissolved solids (TDS) should be monitored daily, and the water balance weekly if required.

In areas where the water is naturally low for calcium hardness and alkalinity, basic water balance chemicals may be required to stop the water being aggressive in the spa pool. However, in commercial spa pools, water replacement frequency should be such that it obviates the need for water balance (depending on the source water). Similarly TDS monitoring may not be required if the water is replaced frequently.

Routine microbiological analysis should also be undertaken to ensure that optimum water treatment conditions are being maintained. While chemical analysis is of benefit to monitor the efficiency of the water treatment system in dealing with the pollution loading, it is important that it is carried out together with microbiological analysis to enable a complete assessment of the water treatment operation and management.

Information obtained from regular monitoring can indicate whether or not water replacement and backwashing are being undertaken at sufficient frequency, disinfectant levels are adequate, show whether or not the operation of the water treatment plant is coping effectively with the bather load, highlight any unnecessary hand dosing of water treatment chemicals, provide information on the condition of the filter bed, and provide advanced warning of failure of filter, pumps, valves etc.

The spa pool manager has the responsibility for ensuring that microbiological samples are taken at appropriate intervals and the results recorded in the spa pool log book together with any remedial actions and follow up samples following an adverse report. In general, a microbiological sample should be taken based on a risk assessment, which would take into account any factors that may have an effect on water quality.

Regular microbiological testing will provide an assurance that operating conditions are satisfactory if it is performed by trained and competent personnel to prevent sample contamination; microbiological analysis is carried out in a laboratory accredited for the analysis to ISO1702551; chemical tests are performed, preferably on site, at the time of sample collection, e.g. pH value and the concentration of free and total disinfectant in the spa pool water, a review of the maintenance records and bather numbers for the spa pool, information on any mechanical failures, the water appearance, and other untoward events is carried out and noted on the sample submission form.

Microbiological samples for indicator organisms should be taken at least once a month as a routine and quarterly for Legionella. More frequent sampling may be required depending on the risk assessment, e.g. if the spa pool is being intensively used and certainly if there are any adverse health effects reported by the bathers. Spa pools that are situated outdoors have additional demands placed on the disinfection and filtration systems from environmental contamination by dust, debris etc., so it is important that such factors are taken into account when determining a monitoring schedule.

If adverse health effects are suspected the enforcing authority (HSE or the Local Authority) and the microbiologist in the testing laboratory should be informed; as required they will then notify the CCDC within the Local Health Protection Unit.

Microbiological sampling should also be done:

- when a spa pool is first used or recommissioned,
- after a report of ill-health following spa pool use
- if there are problems or contamination incidents
- alterations are made to the treatment/maintenance regimes

In summary, spa pools are much smaller than swimming pools. Most of them don't hold much more than 5m^3 of water. There are a number of factors that create an increased risk of legionella pneumophila bacteria colonising a spa pool and its associated plant circulation system:

a) Operating temperature of around 37° C

b) High levels of relative pollution
c) Inaccessible pipework than makes cleaning difficult

Spa pools are also very efficient at dispersing any legionella pneumophila bacteria that have colonised the system due to the aerosol that is created by the action of the air and water jets.

There have been several fatalities in recent years from legionella pneumophila infection where spa pools have been identified as the source.

The following precautions are required:

a) Backwashes should be carried out daily
b) Filter inspections should be carried out every 6 months
c) Free chlorine disinfectant levels should be kept between 3 – 5 mg/l
d) All parts of the system should be thoroughly cleaned every week
e) Microbiological testing for legionella should be carried out every 3 months
f) The entire pool volume should be turned over every day

Much of this chapter contains information from the HSE/HPA publication: 'Management of Spa Pools: Controlling the Risk of Infection. London: Health Protection Agency. March 2006.' This publication can be downloaded in its entirety, free of charge.

Outdoor Pools

Some outdoor pools end up looking more like ponds due to water that is green because of algal growth. Chlorine is broken down by ultra violet light. Sunlight contains ultra violet light and when the sun shines onto an outdoor pool the chlorine gets depleted very quickly. This means that the algae is able to grow unhindered as it will have a source of food, oxygen and sunlight. The pool plant operator needs a way of 'stabilising' the chlorine. Cyanuric acid is used for this purpose. Cyanuric acid binds with the hypochlorous acid (the disinfectant element of chlorine) and makes it more resistant to degradation by UV. The drawback is that it also makes the hypochlorous acid less effective as a disinfectant and for that reason, higher free chlorine residuals must be maintained when using cyanuric acid (2.5 - 5.0 mg/l).

Dosing the correct amount of cyanuric acid can be tricky. Too little and you won't stabilise the chlorine enough, too much and you will over-stabilise and the hypochlorous acid will not be available to act as a disinfectant. The pool plant operator must ensure that the cyanuric acid levels are kept below 200 mg/l, with the ideal range being 50 - 100mg/l. The most effective way of keeping cyanuric acid levels in check is through dilution with fresh water.

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

14. Health & Safety

Risk Management

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.

Hazard identification techniques

Hazard identification is the first, and most important, step of the risk management process on the basis that a hazard must be identified before its corresponding risks can be controlled.

There are many sources of information available to support hazard identification and risk assessment. Broadly these can be categorised based on whether the information is available internally (within the organisation) or externally (sourced outside of the organisation).

Internal sources of information are restricted to the range of experiences within the organisation and can be further limited due to inadequate reporting or poor record keeping.

External sources of information provide opportunities to learn from a much broader field of experience and to benchmark against recognised best practise but may not be directly relevant in the context of a specific organisation.

Internal and external sources are generally complementary and used together help to provide useful, contextual information to help identify hazards and evaluate risks.

Observation

Inspection techniques are observational in nature and involve looking at a workplace, item of equipment or activity to identify hazards – especially those that are not adequately controlled.

Many hazards are not visible to the naked eye and therefore cannot be observed. Some hazards are transient rather than permanent and may not be present at the time of an inspection.

Another factor to consider when using observational techniques is that people can behave very differently when they know they are being watched. Prior notifications of observations can be useful in giving the workforce an opportunity to show that they know how to behave appropriately, follow systems, and wear PPE etc. Unannounced observations should gain a more realist view of what goes on in practise.

Multiple perspectives are useful in safety inspections. Someone with hands on operational experience will have a real-world view of practice, whereas a 'fresh pair of eyes' can often add insight.

Task analysis

Task analysis is a 'catch-all' term for a range of similar techniques that involve taking a task, activity or process and systematically breaking it down into its component steps or actions.

In general health and safety practice a job safety analysis (also known as job step analysis or job hazard analysis) is often used to identify hazards at each action step in a process, with a view to introducing corresponding preventive and / or protective measures.

When using such reductionist (breaking down) techniques it is important not to lose sight of the whole. A holistic view can often lead to a top-level solution that makes more sense overall than a series of lower level solutions.

The basic stages of a job safety analysis can be remembered as SREDIM.

- **Select** an appropriate task to be analysed. JSA is not suitable for jobs defined too broadly e.g. 'overhauling an engine'; or too narrowly, e.g. 'positioning car jack.'
- **Record** each step in the process. Observing somebody actually doing the task helps to ensure the process is accurately captured.
- **Examine** each step to identify hazards. Tools such as MEEP (Materials / Equipment / Environment / People) can be used to help identify all potential hazards – unsafe acts and conditions. A team approach with input from operational and supervisory staff is usually recommended.
- **Develop** a safe system of work using hierarchical approaches to specify appropriate control strategies.
- **Implement** the safe system of work, ensuring appropriate consultation and worker involvement.
- **Monitor** the on-going effectiveness of the system and revise as necessary.

Checklists

Checklists are widely used as an aide memoire in workplace inspections, more so as a monitoring tool rather than for front end hazard identification.

A team desktop exercise could be undertaken to develop a meaningful checklist of likely hazards in a particular workplace. The approach to using checklists must be sufficiently flexible to allow unlisted items to be identified and added during the exercise.

In determining the checklist content grouping inspection items into categories can help make both the inspection process and the reporting easier.

Assessment and evaluation of risk

Definitions

The HSE has defined risk assessment as:

… simply a careful examination of what, in the workplace, could cause harm to people, so that a decision can be made as to whether the precautions taken are satisfactory or whether more should be done to prevent harm.

The key terms of hazard, harm and risk have been defined as follows:

Hazard is anything that may cause harm, such as chemicals, electricity, working from ladders, or an open drawer.

Harm includes:

- ill-health and injury
- damage to property, plant, products or the environment
- production losses or increased liabilities

Risk is the chance, high or low, that somebody could be harmed by a hazard, together with an indication of how serious the harm could be.

The risk assessment process

The HSE advises a basic five steps to risk assessment approach.

Step 1: Identify the hazards

Hazards may arise from: acts such as manual handling; situations such as working at height or in a confined space; or sources of energy such as a radiation source, or the moving parts of a machine.

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

Once the significant hazards have been identified consideration must be given to the people that may be affected and how they may be affected. This will help to identify the best way of managing the risk. This will involve identifying groups of people (e.g. 'people working in the storeroom' or 'passers-by'), and in each case identifying exactly how they might be harmed, (i.e. what type of injury or ill health might occur). For example, 'shelf stackers may suffer back injury from repeated lifting of boxes'.

Some groups of workers are covered by specific legal requirements for risk assessment, e.g. new and young workers, new or expectant mothers and people with disabilities who may be at particular risk.

Other groups of workers who may not be in the workplace all the time may require additional consideration e.g. cleaners, visitors, contractors, maintenance workers etc.

In a shared workplace, the possibility of work activities affecting the health and safety of employees of a neighbouring employer must also be considered. Members of the public must also be considered if they could be hurt by work activities.

Step 3: Evaluate the risks and decide on precautions

Having identified the hazards and who might be harmed it is necessary to determine whether they are effectively controlled. Legally, there is a requirement to do all that is 'reasonably practicable' to protect people from harm.

The first part of the process is to evaluate the risk by considering both the likelihood of harm occurring, and the seriousness of the harm should it occur with current controls in place. This enables risks to be compared and priorities to be established.

A risk assessment should be detailed enough to determine appropriate control measures. Some risk assessment methods are complex and appropriate to special or particularly hazardous activities. For example, risk assessment of a chemical process plant might require complex mathematical calculations of the probabilities of events that could lead to a release of agents that might affect individuals in the workplace or the public.

In many circumstances, risk can be assessed using simpler methods and can be qualitative. These approaches typically involve more judgment, since they place less reliance on quantifiable data. In some cases, these methods will serve as initial screening tools, to determine where a more detailed assessment is needed.

The risk assessment method prescribed in this course uses a scoring system for evaluating the degree of severity of the consequences of exposure or interaction with the hazard and the degree of likelihood that those consequences will occur, considering the systems, procedures and controls in place to prevent it.

The scores given for both consequence and likelihood are multiplied to provide an overall evaluation of risk (sometime referred to as a 'risk rating'). This methodology is presented in a risk rating matrix below.

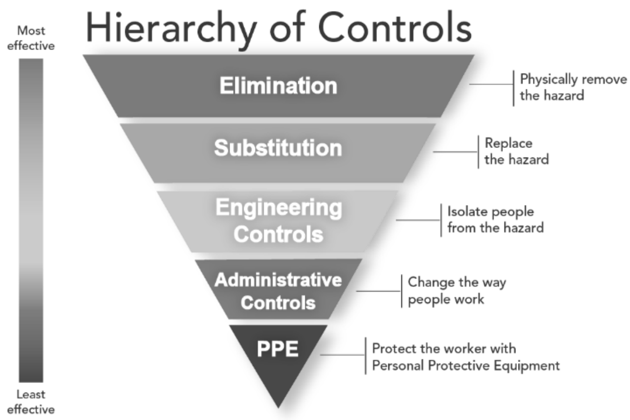
Likelihood					
Very High (no controls in place)	5	10	15	20	25
High (very few controls in place)	4	8	12	16	20
Medium (some controls in place)	3	6	9	12	15
Low (most controls in place)	2	4	6	8	10
Very Low (all controls in place)	1	2	3	4	5
	Slight (no lost time)	Minor (< 7 days absence)	Medium (> 7 days absence)	Major (long term disablement)	Fatal

Consequence

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

Safe systems of work (SSW) and Permits to Work (PTW)

The HSE defines a safe system of work (SSW) as: … *a formal procedure which results from a systematic examination of a task in order to identify all the hazards. It defines safe methods to ensure that hazards are eliminated or risks minimised.*

There are various ways of systematically analysing a task:

A job safety analysis (JSA) may be used to break the task down into its component steps and identify hazards at each stage. Once the hazards have been identified the processes of risk assessment, control and management are worked through as discussed previously.

Hazards may also be systematically identified by considering issues around

- Materials
- Equipment
- Environment
- People

The materials, equipment and environment prompt consideration of unsafe conditions, the people relates to unsafe acts. The MEEP analysis may be used in conjunction with or independent to a JSA.

Another approach considers:

- What plant, equipment or materials are being used?
- Who is responsible for what during the task?
- Where the work is to be undertaken – identifying local hazards.
- How the task is done

A simple SSW may be defined verbally, as a written procedure or become a formal Permit-to-Work (PTW) (discussed later), depending on the level of risk and the needs of the organisation.

In all cases the SSW should:

Consider the preparations and authorisations necessary before beginning work.

a) Ensure the job sequence is logically and clearly planned
b) Specify safe methods for undertaking specific activities
c) Specify safe means of access and egress if relevant
d) Consider the end of activity tasks such as dismantling and disposal

The co-operation of the workforce is essential to the success of the SSW. Employees should be consulted and involved in the development of the SSW. The need for and the content of the SSW and management's commitment to it must be clearly communicated to all employees.

Any necessary tools, equipment or additional resources will need to be sourced and made readily available prior to implementation.

Managers and supervisors will also require training to enable the effective implementation and on-going monitoring of the SSW.

Once implemented the SSW will require periodic monitoring to ensure:

a) The system is workable and employees are comfortable following it (employee feedback should be encouraged)
b) The procedures as specified are being followed and are effective
c) Any changes to the workplace or work practises that would necessitate a review and reiteration of the SSW are identified early

Permit-to-work

A permit-to-work (PTW) system is a formal recorded process used to control work which is identified as potentially hazardous. It is also a means of communication between the various parties who carry out the hazardous work.

Essential features of permit-to-work systems are:

a) Clear identification of persons responsible for authorising particular jobs (and any limits to their authority) and persons responsible for specifying necessary precautions
b) Clear identification of the types of hazardous work
c) Clear and standardised identification of tasks, risk assessments, permitted task duration and supplemental or simultaneous activity and control measures
d) Training and instruction in the issue, use and closure of permits
e) Monitoring and auditing to ensure that the system works as intended

Basic process

a) Issue by a competent issuing authority setting the parameters of the permit and confirming that precautions are in place
b) Acceptance by a competent worker (performing authority) confirming understanding of the work to be done, hazards involved and corresponding precautions
c) Hand-back of the PTW, by the performing authority, confirming that the work has been completed to plan
d) Cancellation of the PTW by the issuing authority confirming the work has been tested and the work area returned to normal use

Additional procedures are required for extension of agreed time limits if necessary and for managing shift handovers.

When the need for a PTW is identified, the first part of the process should be to determine exactly what the task will involve, including:

a) The need for any special safety studies or risk assessments (e.g. task risk assessment, CoSHH, manual handling)
b) If the likely hazards cannot be reconciled at this stage then the task should be rejected or redefined
c) The personal competency requirements needed to undertake the work, isolations, or safety support, for example: visual support for over-side work, additional personnel for confined space entry

Any work involved in the PTW system, should be part of the integrated planning process for the site. If the risk assessment identifies hazards that cannot be addressed, or if the proposed task will pose unacceptable risks for people at the site, then the work should not be permitted. A safer method will need to be identified.

Copies of a PTW should be clearly displayed:

a) at the work site, or in a recognised location near to the work site; and
b) in the central or main control or permit co-ordination room.

A copy of the permit should be kept with the issuing authority, or the area authority.

Work may sometimes need to be suspended, for example:

a) general alarm
b) operational reasons, such as conflicts with other permits or scoped works
c) waiting for spares
d) changes to the nature or scope of the work

Note: a suspended PTW remains live until it is cancelled so there may still be active isolations under a suspended PTW. Records of suspended permits should be kept live with information on the condition in which the plant has been left and the consequences for other activities. Work should not be restarted until the issuing authority has verified that it is safe to do so, and has revalidated the permit or issued a new permit.

Checks should be made to ensure that one activity under a PTW does not create danger for another, even if the other work does not require a PTW. Potential interactions with other live or planned activities should be considered during the preparation of a PTW.

If the interacting activities are covered by separate responsible authorities close liaison and cross referencing of PTW will be necessary. This is likely to be key with isolation procedures if an isolation is common to more than one job.

Handover

When a job takes longer than expected and work has to be carried over to another shift, a shift handover procedure should be in place. The handover procedure should make the incoming shift aware of:

a) any outstanding permit controlled jobs
b) the status of those jobs
c) the status of the plant

Work-in-progress should be left in a condition that can be reliably communicated to, and understood by, the oncoming shift. Good communication between incoming and outgoing issuing and performing authorities is essential.

Hand-back

The hand-back procedure should include obtaining answers to the following questions:

a) Has the work been completed? (to be confirmed by the performing authority)
b) Has the plant or equipment been returned to a safe condition? (for example: removing isolations)
c) Has this been verified by the person responsible for signing off the PTW (i.e. issuing or area authority)
d) Has the person in control of operational activities acknowledged on the PTW that the plant or equipment has been returned to the control of the production staff?

Use of permits

PTW systems should be considered for work activities which may adversely affect the safety of personnel, plant or the environment. However PTW systems should not be applied to all activities, as this has been shown to reduce the overall effectiveness of PTW systems. PTW are not required for controlling visitor access or routine maintenance work in non-hazardous areas.

PTW are useful in controlling: non-routine operations; jobs where two or more individuals or groups need to co-ordinate activities to complete the job safely; and jobs where there is a transfer of work and responsibilities from one group to another.

Control of Substances Hazardous to Health Regulations 2002 (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.

Factors to Consider when Assessing Risks

The purpose of CoSHH risk assessment is to enable employers to make valid decisions about the measures necessary to prevent or adequately control the exposure of their employees to substances hazardous to health arising from the work. It also enables the employer to demonstrate readily, both to themselves and to others who may have an interest, for example: safety representatives, enforcement authorities etc. that they have:

- Considered all the factors pertinent to the work
- Reached an informed and valid judgement about the risks
- Considered the practicability of preventing exposure to hazardous substances

- Considered the steps which need to be taken to achieve and maintain adequate control of exposure where prevention is not reasonably practicable
- Considered the need for monitoring exposure at the workplace and for health surveillance
- Identified other action necessary to comply with regulations.

In order to achieve the above it is necessary to consider a range of factors in each CoSHH risk assessment.

The hazardous properties of a substance

It is essential to find out what hazardous properties hazardous substances have, for example: toxic, corrosive, harmful etc. and what sort of harm could result from exposure to a chemical or biological hazard, for example: whether exposure could cause:

- Serious effects or death, either immediate or delayed, occur from single exposures to the substances, i.e. the effects of acute exposure
- Adverse effects or death result from repeated, even low level, exposures over a period of time, i.e. the chronic exposures
- Both long-term and short-term effects, i.e. the effect of acute and chronic exposure
- Cancers
- Sensitisation, allergic reactions or asthma
- Dermatitis
- Harmful effects to the human reproductive process
- Micro-organisms cause infection or could an infected individual infect others.

The level of exposure

The level of exposures requires CoSHH risk assessments to consider what substances are likely to be present and in what form, for example: dust, vapour, mist, fume etc. and in what concentration.

Route of entry

Routes of entry include; inhalation; skin contact; ingestion; exposure through the eyes and ears; and injection. The route of entry is directly related to the physical form of the chemical. Airborne chemicals will be available to the breathing zone; pastes will cause skin contact etc.

Particle size of solids

The physical property for solids is a subjective assessment of the material's 'dustiness'. CoSHH Essentials uses simple descriptors of dustiness to put a substance into a high, medium or low dustiness band:

- Low: Pellet - does not break up (calcium hypochlorite pellets)
- Medium: Granular or crystalline (aluminium sulphate)
- High: Fine solid and light powder (sodium bisulphate)

Each of the categories reflects the risk of inhalation i.e. high presents a high probability of inhalation etc.

Where a task is likely to generate an aerosol from a liquid, there is also a significant increase in the exposure potential. Aerosols are formed by:

- Spraying and printing
- Electroplating with gas generation
- Hot vapour condensation (fume)
- Dispersal through contact with fast-moving machinery
- Decompression, such as a pre-packaged hand-held aerosol spray product

Volatility of liquids

The volatility of a substance is a measure of the tendency of that substance to vaporise. Volatile organic compounds are substances that can evaporate at normal temperature and pressure and therefore present a particular risk. The lower the boiling point, the more vapour will be available and the higher the risk.

Concentration

The concentration of a substance is directly linked to the toxicity. Therefore, the higher the concentration, the more toxic the dose, for example: toxic substance at 100% concentration may become a harmful substance at 50% concentration and not classified as hazardous under CHIP4 at a 5% solution.

The concentration is expressed as:

- LD50: the ingested dose which kills 50% of the test population, measured in milligrams/micrograms per kilogram of body weight.
- LC50: airborne concentration of a toxic substance lethal to 50% of the test population, measured in millilitres per kilogram of body weight.

Concentration is also linked to the amount of toxic substance. The greater the quantity, potentially, the greater the dose received.

Solubility

The solubility of a substance (i.e. whether or not it dissolves in water or fat [lipid]) will determine both the route of the substance into the human body and the tissues in which it will accumulate. Should it accumulate in sufficiently high concentrations the effects will be toxic.

The nature of the task

The nature of the task will also affect exposure to hazardous substances.

Employees may be exposed:

- Directly i.e. by doing the task
- Indirectly i.e. by passive exposure to the hazardous substance in the work area
- Undertaking cleaning or maintenance tasks
- By contact with contaminated work areas, clothing etc.

- Accidental release of a hazardous substance.

A task involving a physical job which produces a large amount of dust, for example: transferring calcium hypochlorite pellets to a hopper, will produce a greater exposure.

The number of people exposed

The risk assessment will need to consider the ways in which and the extent to which any groups of people could be exposed, including maintenance workers who may work in circumstances where exposure is foreseeably higher than normal: office staff, night cleaners, security guards, members of the public such as visitors, patients etc. Minimising the number of people exposed is a key part of the hierarchy of control. The more people exposed the greater the need to use collective measures, i.e. controlling the hazardous substance at source, rather than individual measures.

Type and duration of exposure

The dose of substance received is the product of the concentration to which workers are exposed and the duration of exposure. Therefore, reducing the exposure time will reduce the dose received. This can be achieved by job rotation. An estimate of exposure will also need to take into account the effort needed to do the work and how this may affect the rate and volume of air employees breathe (for some work activities, employees might breathe three or four times the volume of air that they would breathe at rest).

Frequency of exposure

Chemicals can have an adverse health effect as a result of:

- Sudden or short term high exposures (acute toxicity).
- Repeated low exposures over time (chronic toxicity).

Some chemicals can cause both acute and chronic toxicity depending on the conditions of exposure, for example:

- Acute: drinking too many units of alcohol on an evening out can result in mood changes, nausea, vomiting and hangovers.
- Chronic: excessive drinking of alcohol over time can lead to coronary heart disease, strokes, high blood pressure, liver damage, cirrhosis of the liver, cancers of the mouth and throat and psychological problems such as depression.

Mixtures of chemicals

Where a work activity may expose employees to more than one substance hazardous to health, the possible enhanced harmful effects of combined or sequential exposures must be considered. Information is usually available in section 10 of Safety Data Sheets: ‘Stability and Reactivity’.

There may be a number of effects:

- Additive effects: The combined effect equals the sum of the effects of each chemical alone, i.e. 1 + 1 = 2. Example: organophosphate pesticides, such as parathion.

- Synergistic effects: The combined effect is larger than the sum of the effects of each chemical alone, i.e. 1 + 1 = 40. An example of an increase in risk is with asbestos fibres and cigarette smoking. They act together: the risk of developing lung cancer after exposure to asbestos fibres is forty times greater for a smoker than for a non-smoker. Another pair of the chemicals where the combined risk is greater than a mere additive effect are the solvents trichloroethylene and styrene.

- Antagonistic effects: The combined effect is less than the sum of the effects of each chemical alone, i.e. 1 + 1 = 0. This effect is used to find an antidote to a poison.

- Potentiating effects: A chemical that normally has no effect will increase the effect that another chemical would have alone, i.e. 0 + 1 = 3. Example: two commonly used solvents, isopropanol and carbon tetrachloride, have this kind of joint effect. Isopropanol, at concentrations which are not harmful to the liver, increases the liver damage caused by carbon tetrachloride.

Activities causing high exposure

It is important to give particular consideration to activities which can give rise to the highest exposures, for example: cleaning of equipment, work in confined spaces (such as swimming pool balance tanks and filter vessels etc.), or non-routine or end-of-shift tasks. Understanding the factors that contribute to employees' exposure will help decide how to control it. It is particularly important for repair or maintenance work involving the opening of vessels or breaking into pipework to be carried out under the control of a 'permit-to-work' system. For this work, identifying the hazardous substances in a container or pipe is one essential element of the risk assessment that must be carried out before the work starts. To carry out suitable and sufficient assessments of the work in these circumstances, a system must be in place, which identifies:

- The name/s of the hazardous substances which containers and pipes contain or contained
- The form the hazardous substance/s takes, for example: liquid, semi-liquid, sludge, powder, waste mixed with other identified material
- The hazards the substance/s could pose if employees were exposed to the contents, for example: irritation or burns to the skin from spilt liquids.

An accident, incident or emergency could cause a high exposure to a hazardous substance. CoSHH defines such an event as one which causes, or threatens to cause, any employee to be exposed to one or more hazardous substance on a scale, or to an extent, well beyond that associated with normal day-to-day activity.

For example, any one of the following events may be sufficient to trigger the emergency actions considered by CoSHH:

- Any serious process fire which could give rise to a serious risk to health.

- Any serious spillage or flood of a corrosive agent liable to make contact with employees’ skin.
- Any failure to contain biological, carcinogenic or mutagenic agents.
- Any acute process failure that could lead to a sudden release of chemicals, for example: an exothermic reaction that results in emission of toxic fumes.
- Any threatened significant exposure over a WEL, for example: where the exposure is clearly the result of an unusual, sudden and serious failure of LEV or other controls.

Thresholds of exposure

The threshold limit of a chemical substance is a level to which it is believed a worker can be exposed day after day for a working lifetime without adverse health effects. The threshold limit is an estimate based on the known toxicity in humans or animals of a given chemical substance, and the reliability and accuracy of the latest sampling and analytical methods. It is not a static definition since new research can often modify the risk assessment of substances and new laboratory or instrumental analysis methods can improve analytical detection limits.

Effectiveness of existing control measures

Effective procedures should be used to ensure that control measures, including items of personal protective equipment and any other measure, are properly used or applied and are not made less effective by other work practices or by improper use.

The procedures should include:

- Visual checks and observations at appropriate intervals.
- Ensuring that where more than one item of PPE is being worn, the different items are compatible with each other.
- Supervising employees to ensure that the defined methods of work are being followed.
- Prompt remedial action where necessary.

It is also essential to ensure that every element of a control measure performs as originally intended, and continues to adequately control the exposure of employees to substances hazardous to health. This includes the identification of any significant deterioration in any element of the control measure, and the taking of any necessary corrective steps. The frequency of any checks carried out will depend on the likelihood of significant deterioration of that particular element of the control measure and its importance. As a minimum it should be done at intervals of not more than one year and after any incidents.

This may include:

- visual checks
- inspection
- servicing
- observation of systems of work
- any remedial work to maintain the effectiveness of control measures

Anyone who checks the effectiveness of any element of a control measure should have the competence to do so. The degree of theoretical and practical knowledge required will increase with the likelihood of control failure, the seriousness of the consequences, and the complexity of the control measure.

Individual susceptibilities

Employers are required to protect particular groups of employees who may be at an increased risk, for example:

- Inexperienced trainees and young people aged under 18
- Pregnant workers
- Disabled workers
- Any employees known to be susceptible to certain illnesses such as dermatitis
- Any employee suffering atopic (allergic) asthma due to pollen, or eczema due to dust mites etc. may consequently be at more risk of sensitisation to a work exposure to a sensitising agent
- Any employee known to be previously sensitised to a work based skin or asthma sensitising agent
- Any employee with pre-existing medical conditions, which could be made worse by exposure to chemicals

COSHH control measures

Regulation 7 of CoSHH requires the employer to prevent employees' exposure to hazardous substances 'so far as is reasonably practicable' and where prevention is not reasonably practicable to implement adequate controls. Where there is a WEL, exposure must be kept below the WEL. However, exposure to carcinogens, mutagens and asthmagens must be kept 'as low as is reasonable practicable.' This is a higher duty of care than 'so far as is reasonably practicable because the severity of the ill-health is high and there is no 'safe' level of use.

Principles of good practice

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. Take into account 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.

Minimise emission, release and spread of substances hazardous to health

It is more effective, and usually cheaper, to reduce the emission of a contaminant at source, rather than to develop ways of removing the contaminant from the workplace, once it has been released and dispersed. Sources of exposure should be reduced in number, size, emission or release rate, as much as possible. It is often not possible to obtain adequate and reliable control unless this is done. Both the processes and procedures need to be considered. To identify how people get exposed during work activities, it is essential to recognise the principal sources and how the contaminant is transferred within the workplace. It is easy to miss significant sources and causes of exposure. It is best to do this at the design stage, but it may well be possible to make useful and relatively low-cost changes to existing processes. Identify and control the worst sources first.

People working near a process may be significantly exposed even though those directly involved are protected, for example: by wearing PPE. In these circumstances, the most practical option may be to segregate the process. It may be the only viable way to protect those people not directly involved in the process or activity. Once the number and size of sources have been minimised, consider reducing emissions by enclosure or other means.

Design work methods and organisation to minimise exposure

This normally requires clearly defined and described work methods. Organise the work to minimise the number of people exposed and the duration, frequency and level of exposure.

In addition to identifying significant sources, it is essential to identify and consider all work groups that may be exposed. It is easy to miss or underestimate the exposure of those engaged in non-routine activities such as work done by maintenance personnel and contractors.

Also, it is important to be aware of, and have contingency plans for dealing with, failures of control and emergencies.

Take into account all routes of exposure

The physical, chemical and infectious properties of a substance have a great bearing on which route of exposure, or combination of routes, is most important. In some cases, it might be immediately obvious that not all routes apply.

Therefore:

- Identify all sources and routes of exposure.
- Rank these routes in order of importance.

Where inhalation is the most relevant route, the main focus for control will be sources of emission to air. Where the main concern is ingestion or effects on, or as a result of penetration through the skin, then the main focus for control will be sources of contamination of surfaces or clothing and direct contamination of the skin. Exposure assessments should identify and, if at all possible, grade or rank the contribution of all routes of exposure (inhalation, skin and ingestion) to total exposure. In this way control effort can be directed at the main sources and causes of exposure. Prevent skin contact where possible if contamination may lead to skin absorption, ingestion or direct health effects on the skin. Regularly clean all surfaces that can become contaminated. The frequency of cleaning should be based on the rate at which the surfaces become contaminated and how often skin is likely to come into contact with them. If the workroom is likely to become contaminated, and this contamination may contribute significantly to exposure, people should not increase their exposure by activities, for example: eating, drinking, smoking, or using cosmetics in the workplace.

Control exposure by measures proportionate to risk

The more severe the potential health effect and the greater the likelihood of it occurring, the stricter the measures required to control exposure. If the health effects arising from exposure are less serious, for example: simple, reversible irritation, and are not likely to cause long-term harm, it may be sufficient to reduce exposure by simple, low-cost measures such as replacing lids on vessels or cleaning work areas regularly.

Where the health effects arising from exposure are more serious, for example: cancer, asthma, allergic dermatitis, severe disease or other irreversible and disabling health effects, and there is not enough information to establish a no-effect level (biological agents will not have a no-effect level), then exposure will need to be reduced to low levels. The control measures necessary might be extensive, take time to develop and implement, and be relatively costly.

The measures should control the risk of both long-term (chronic) and short-term (acute) health effects.

Choose the most effective and reliable controls

Some control options are more reliable and effective than others, for example:

- Personal protective equipment: the protection afforded by PPE is dependent upon good fit, attention to detail and correct use by an individual, and is therefore not very reliable.
- Changing the process so that less of the hazardous substance is emitted or released at source is a very reliable form of control.

The key message is that there is a hierarchy of reliability of control options and this is often linked to their effectiveness.

Where exposure cannot be controlled by other means, provide PPE with other controls

Giving people PPE such as gloves or respirators may appear to be the quick, cheap and easy option. In practice, it is likely to be the least reliable and effective option. It may not actually be the cheapest if a PPE programme is compared like- for-like with the cost of providing other control options.

PPE tends to be less effective and reliable than other control options, because it:

- Has to be selected for the individual
- Has to fit the individual and not interfere with their work or other PPE worn at the same time
- Has to be put on correctly every time it is worn
- Has to remain properly fitted all the time the individual is exposed
- Has to be properly stored, checked and maintained
- Tends to be delicate and relatively easily damaged
- Fails to danger, sometimes without warning.

It may be necessary to include PPE in a mix of control measures.

Check and review control measures

Once an effective set of workable control measures have been devised, they need to be put in place and managed. This includes training all relevant people in the use and maintenance of the control measures. The requirement for maintenance is important to achieve effective and sustained control.

Maintenance of control measures includes: defined methods of working, supervisory actions, record keeping etc.

Whatever is equipment involved must be checked and must continue to function as intended. But a similar approach needs to be taken to check the actions people must take and the methods of working they need to adopt. These need checking and correcting too.

The effectiveness of control measures should be checked regularly. Exactly what checks should be done will depend on:

- The control measures in use
- How reliably they control exposure
- How well characterised they are
- The consequences of control degradation or failure

Inform and train all employees on hazards and risks

For control measures to be effective, people need to know how to use them properly. Most importantly, people need to know why they should work in a certain way and use the controls as specified; they need to be motivated.

People also need to know how to recognise when control measures are not working properly. This means training operators, and also supervisors and managers.

Ensure that control measure do not increase the overall risk

Process changes, enclosures, ventilation, new methods of working, PPE and other changes to control exposure can introduce new risks, for example:

- Process changes might mean that equipment cannot be fully decontaminated before maintenance staff are given repairs to do
- New methods of working may create risks of musculoskeletal injury

People designing control measures should look for these 'new' risks and minimise them. They must not only focus on the risk from substances hazardous to health. A good control solution is one which minimises the health risk, while reducing maintenance burdens, being relatively fool-proof, and not introducing other risks.

Personal protective equipment

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. Some or all of the following protective clothing may be needed during delivery, handling of materials, cleaning or maintenance:

- dust masks and face protection
- eye protection (to British Standard EN 166:200250)
- aprons or chemical suits
- boots
- gauntlets
- respirators

Respirators

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 particularly important to provide precautions against exposure to toxic gases. Sufficient canister respirators for all employees liable to be present at any one time should be kept available in or near plant rooms. Canister respirators should be located in the immediate area where the leak may occur and also at the entrance door to these areas where they can be used by staff who may have to go into the area where a leak is apparent.

Employees who have to work with the chemicals should have respirators on personal issue. The type of respirator, training, instructions and maintenance arrangements should be determined as part of the assessments.

Canister respirators can only deal with low concentrations of toxic gases. Pool operators need to consider suitable emergency procedures for more serious leaks, where appropriate in consultation with the fire authorities. Canister respirators should only be used as a last resort. Where they are used, it is important that attention be 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.

Delivery, storage and handling 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.

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.

Delivery on site

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.

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.

Storage

Storage rooms should:

- be clearly marked, warning of the possible danger, and be secure locations accessible only by authorised employees
- not be plant rooms unless the chemicals carry no risk of fire and are contained in bunds of suitable design

- be at the same level as the delivery point and accessed directly from outside (ideally by ramp rather than steps). This will assist ventilation, and movement of materials (including in an emergency)
- not be situated close to public areas, doors, windows or ventilation intakes. This reduces the risk of any release of toxic fumes being drawn into the building
- have adequate natural ventilation to the open air in a safe position (ie, not to a public area, or to a place from where fumes may enter the building). If adequate natural ventilation is not reasonably practicable, mechanical ventilation should be provided. Where failure of ventilation would pose a serious hazard (eg, for a chlorine gas store), a flow switch should be incorporated in any mechanical system to sound an alarm in case of fan breakdown. However, chlorine gas is safest when stored in a specially designed sealed room that in case of a major leakage from a cylinder prevents the gas from escaping
- provide clean and dry storage for solid materials (raised on pallets or stilts to avoid contact with any water which may enter the store)
- protect containers from direct sunlight, and isolate them from hot pipework or plant

In addition, it is important that storage rooms also provide enclosures with a minimum of half an hour fire resistance for all chemicals, in view of risks from over-heating, such as:

- fire
- dangerous fumes being given off
- leakage from damaged plastic containers
- explosion of pressurised containers

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.

Plant rooms should not be used for general storage, or for storage of chemicals. Plant rooms should be large enough to accommodate the equipment and also to allow people to move around without exposing themselves to hazards. Access to plant rooms and chemical stores should be restricted to only those personnel who have are deemed competent enough to be in there.

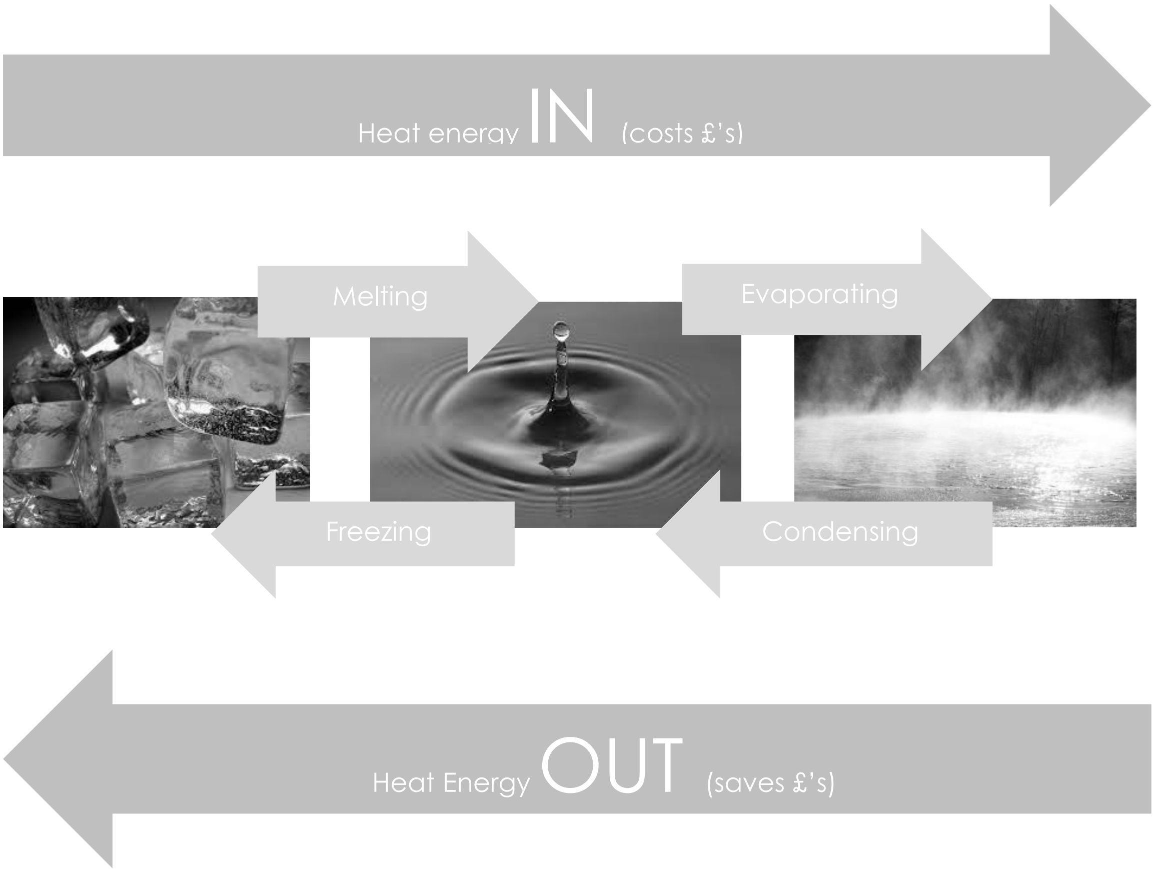
Handling of chemicals

Employees will need protection against some chemicals. The risk assessment must take this into consideration and determine the most appropriate protection to be used. Safe systems of work should be followed to protect employees from contacting, ingesting or inhaling harmful materials. For example: conditions for weighing and mixing materials should be carefully controlled and protective equipment supplied, mixing areas must be ventilated, and local exhaust ventilation will need to be considered. Smoking should be prohibited when handling chemicals.

15. Air Handling and Energy Efficiency

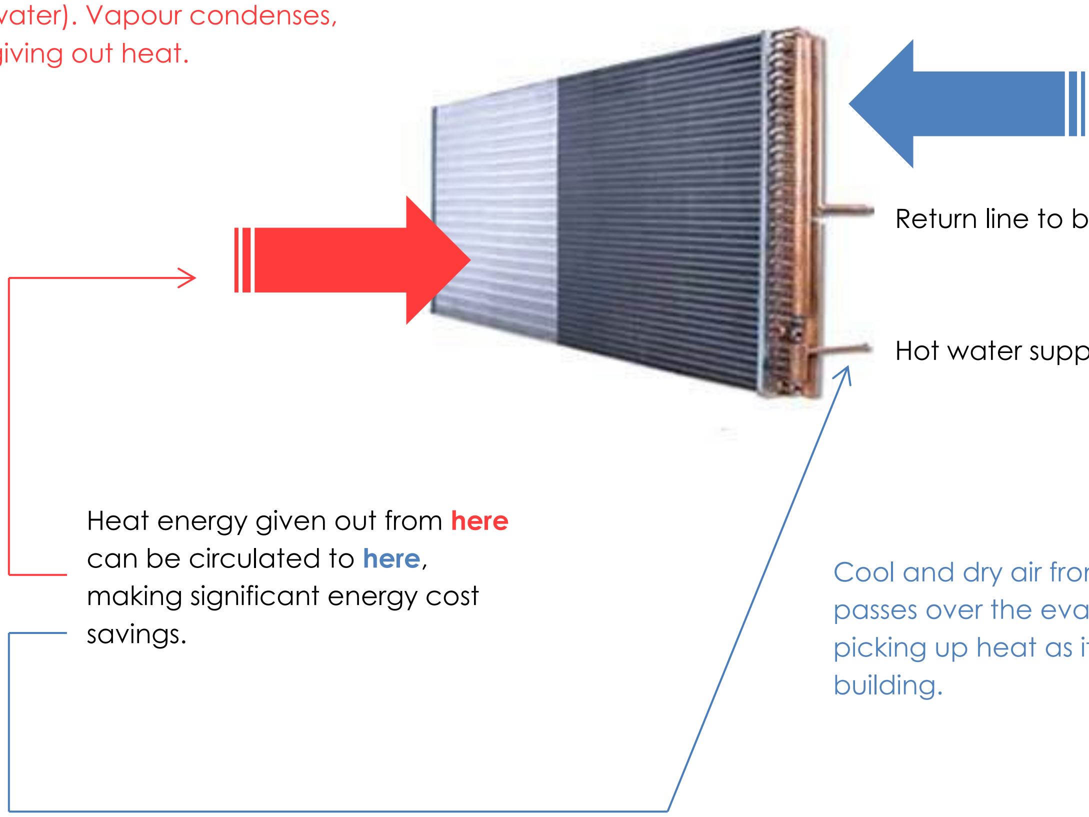
The first thing to know regarding air handling and energy efficiency is that in a swimming pool, air handling is the single biggest energy cost. In fact, the energy cost is so big that it can be more than the combined cost of all the other energy being used by the facility!

What needs to be understood is the relationships between heat energy and substance phase.



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.

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.

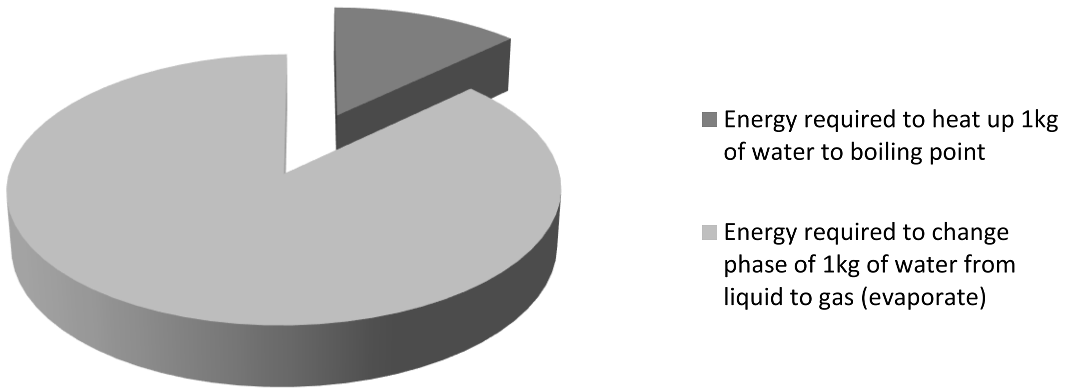
Condensation

One of the main problems for many swimming pools is condensation. Condensation occurs when a substance (in our 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. As soon as it drops below that temperature (for example, when it penetrates into the porous concrete walls of a building) 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. The relative humidity refers to the amount of water vapour in the air, expressed as a percentage of the maximum possible amount of water vapour there could possibly be in the air at that time. A relative humidity of 100% means that the air is holding the maximum amount of water vapour that it possibly could and is therefore said to have reached saturation. Warm air is capable of holding more water vapour than cool air.

Evaporation

Evaporation is the opposite of condensation. It happens when a substance changes phase from liquid to gas. It requires a large amount of heat energy input to bring about this change of phase; in fact, it takes far more energy to do this than it takes to heat up a substance in the first place.



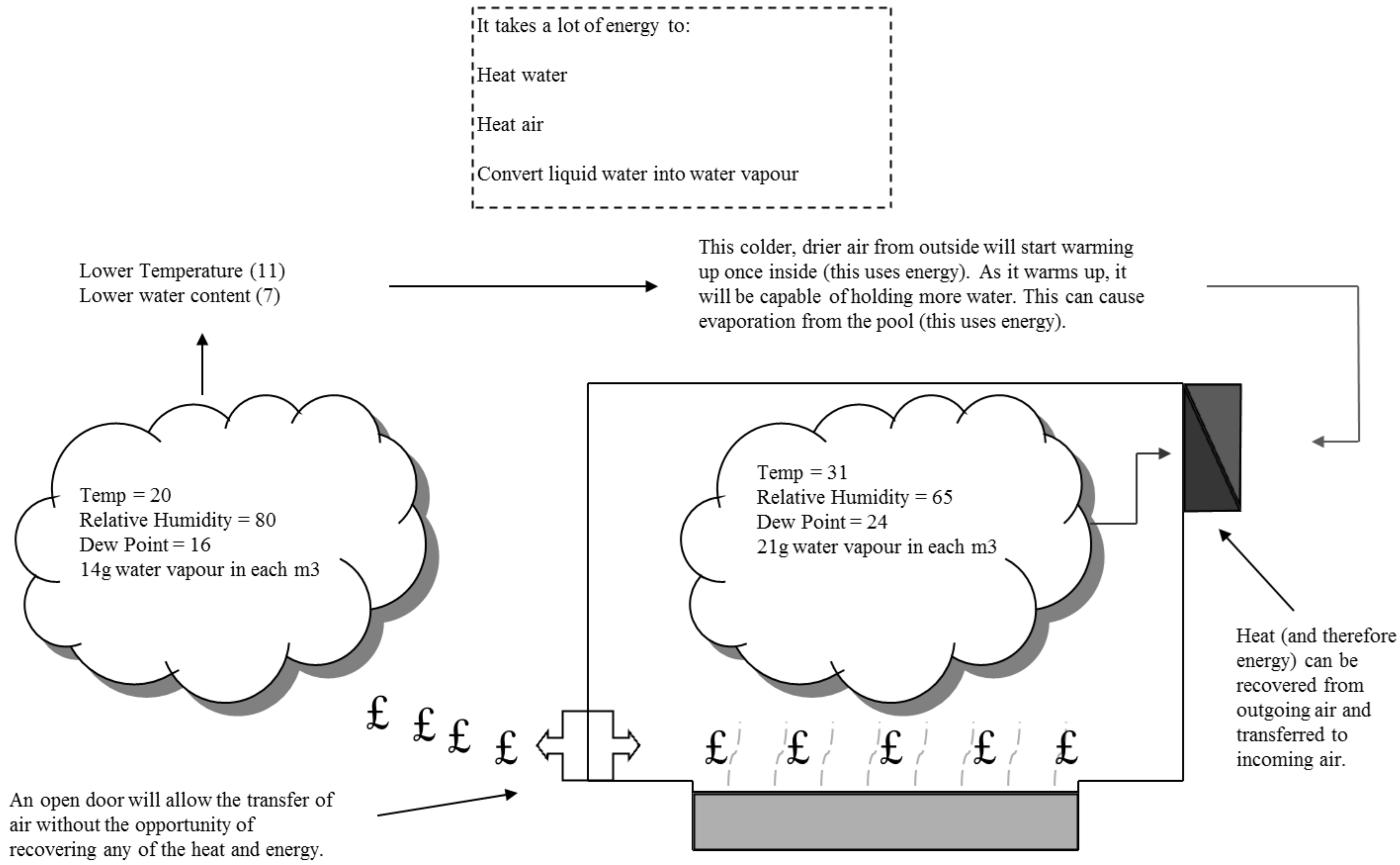
Energy required to change phase of water

Evaporation can have a big impact on energy bills because, as we have seen, it takes a large amount of energy to bring about a change of phase of a substance, which is exactly what is happening when water evaporates from the surface of the swimming pool.

Relative Humidity

This 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 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.


It takes a lot of energy to:
Heat water
Heat air
Convert liquid water into water vapour
Lower Temperature (11)
Lower water content (7)
This colder, drier air from outside will start warming up once inside (this uses energy). As it warms up, it will be capable of holding more water. This can cause evaporation from the pool (this uses energy).
Temp = 20
Relative Humidity = 80
Dew Point = 16
14g water vapour in each m3
Temp = 31
Relative Humidity = 65
Dew Point = 24
21g water vapour in each m3
Heat (and therefore energy) can be recovered from outgoing air and transferred to incoming air.
£ £ £ £
£ £ £ £ £
An open door will allow the transfer of air without the opportunity of recovering any of the heat and energy.

Other ways of energy saving

Dilution rates

In order to control levels of chemical pollution it is important to dilute the pool with fresh make-up water. The recommended dilution rate is:

- 30 litres of fresh water per bather, per day

This amount of fresh water can add up to quite a lot, especially in busy swimming pools with high footfall. All this water can be costly, not just because of the cost of the water itself, but also because of the costs associated with heating it up to bathing temperature and chemically treating it.

The backwash process will be the main method of dilution. The water that is discharged to drainage during a backwash is either made-up after the backwash, or the pool is pre-filled prior to the back wash. Evaporation will also be removing a comparatively small amount of water from the pool, as will water being displaced by bathers. Usually though, these things do not meet the required dilution rate and it is necessary to 'dump' water in order to achieve the required level of dilution.

As an alternative to this wasteful dumping of water, at may be possible to plumb the supply to the pre-swim showers and toilet cisterns etc. from the swimming pool water instead of the mains. That way, whenever someone flushes the toilet of 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 and also good for combating the bad smells that can sometimes emanate from wet-side changing room toilet areas).

Pump redundancy

Whilst bathing as taking place it's important that the required turnover time is achieved in order to provide quality swimming pool water. When the pool is out of use though, the requirement to achieve the turnover time can be relaxed. This can enable operators to turn one of 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.

Grey water harvesting

Grey water refers to waste water that is not sewage (which is referred to as black water). It would include the water that is discharged to drainage during a backwash procedure. In many facilities, this backwash water is simply wasted. In a grey water harvesting system, the backwash water is retained in a vessel (sometimes located underground) from where the heat that is still present in the water can be transferred via a simple circulation system to where it is needed (the pool water heat exchange system, for example).

Exercise 1: Relative Pollution

Calculate the pool volume for each pool listed in the table below and then calculate which pool would have the highest level of relative pollution.

Type of pool	Length	Width	Average depth	Number of bathers
Traditional	20 m	12 m	1.5 m	60
Teaching	10 m	6 m	0.5 m	12
Spa	2 m	2 m	0.5 m	8

Exercise 2: Chemical Names and Uses

Put the following chemicals into the appropriate space in the table below, according to its main purpose:

- Sodium Carbonate
- Calcium Hypochlorite
- Sodium Bisulphate
- Sodium Hypochlorite
- Polyaluminium Chloride
- Carbon Dioxide
- Calcium Chloride
- Sodium Bicarbonate
- Sodium Thiosulphate

Increases

Disinfectant	pH Correctant	Coagulant	Total Alkalinity	Calcium Hardness

Decreases

Appendix 1: Plant Room Visit Items

What type is the water surface draw-off system?	
How many 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?	
What is the diameter of the filter(s)?	
Are there inlet and outlet pressure gauges fitted to the filters? If yes, what are the readings?	
Based on the filter pressure readings, do the filter(s) need to be backwashed?	
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?	
What are the primary hot water flow and return temperatures?	
What is the pool water heated temperature?	
Are all the chemicals being stored safely? If not, what issues have you identified?	

Appendix 2: Suggested PPM Schedule

Frequency	Item(s)	Observations/Actions	Carried out by
Daily	Day tanks	Chemical levels correct, no leakages	Pool Plant Operator
Daily	Pressure gauges	Correct pressure	Pool Plant Operator
Daily	Flow meter	Correct flow rate	Pool Plant Operator
Daily	Auto-dosing control panel	Correct readings	Pool Plant Operator
Daily	Filter(s)	Backwash (spa's only)	Pool Plant Operator
Daily	Pool water	Test free, total chlorine and pH (several times daily)	Pool Plant Operator
Weekly	Filter(s)	Backwash (pools)	Pool Plant Operator
Weekly	Pre-pump strainers	Clean	Pool Plant Operator
Weekly	Auto-dosing control panel	Check calibration (compare against DPD1/Phenol red tests)	Pool Plant Operator
Weekly	Filter(s)	Air release valves operational	Pool Plant Operator
Weekly	Stainless steel surfaces	Wipe clean	Pool Plant Operator
Weekly	Pool water	Water balance test	Pool Plant Operator
Weekly	Pool water	Microbiological tests (hydrotherapy pools only)	UKAS Accredited laboratory
Weekly	Balance tank(s)	Drain and clean (spa's only)	Pool Plant Operator

Monthly	Pool water	Microbiological tests (all other pools)	UKAS Accredited laboratory
Monthly	Auto-dosing control panel	Re-calibrate	Pool Plant Operator
Monthly	Deck-level overflow channels	Drain, clean and flush	Pool Plant Operator
3 Monthly	Pool Water	Legionella bacteria tests (spa's only)	UKAS Accredited laboratory
6 Monthly	Filter(s)	Media bed inspection (spa's only)	Competent contractor
6 Monthly	Balance tank(s)	Drain and clean	Competent contractor
6 Monthly	Chemical dosing system	Full service	Competent contractor
6 Monthly	Ozone systems	Full service	Competent contractor
6 Monthly	UV systems	Full service	Competent contractor
Annually	Filter(s)	Full inspection and report	Competent contractor
5-7 Years	Filter(s)	Media replacement	Competent contractor

Appendix 3: Pool Water Testing Parameters and Frequencies

Test	Target Parameter	Frequency	Action: Too High	Action: Too Low
Free Chlorine	Pools: 1.00 – 3.00 mg/l, reducing to 0.50 - 1.00 mg/l once consistent satisfactory microbiological tests results have been established. Spa's: 3.00 – 5.00 mg/l Pools using stabilised chlorine: 2.50 – 5.00 mg/l	Before opening and then every 2 hours during use (less if auto-monitored, but will depend on bathing load).	Dilute, or add sodium thiosulphate (5g per gram of excess chlorine)	Cease bathing, add more disinfectant.
Total Chlorine	See below	Before opening and then every 2 hours during use (less if auto-monitored, but will depend on bathing load).	See below	See below.
Combined Chlorine	< 50% of free chlorine AND < 1.00 mg/l	Before opening and then every 2 hours during use (less if auto-monitored, but will depend on bathing load).	Dilute, review pre-swim showering, reduce bathing load, backwash filters	Not applicable – try and get it as low as possible.
Total Bromine (if bromine used as a disinfectant)	4.00 – 6.00 mg/l	Before opening and then every 2 hours during use (less if auto-monitored, but	Dilute, or add sodium thiosulphate (5g per gram of	Cease bathing, add

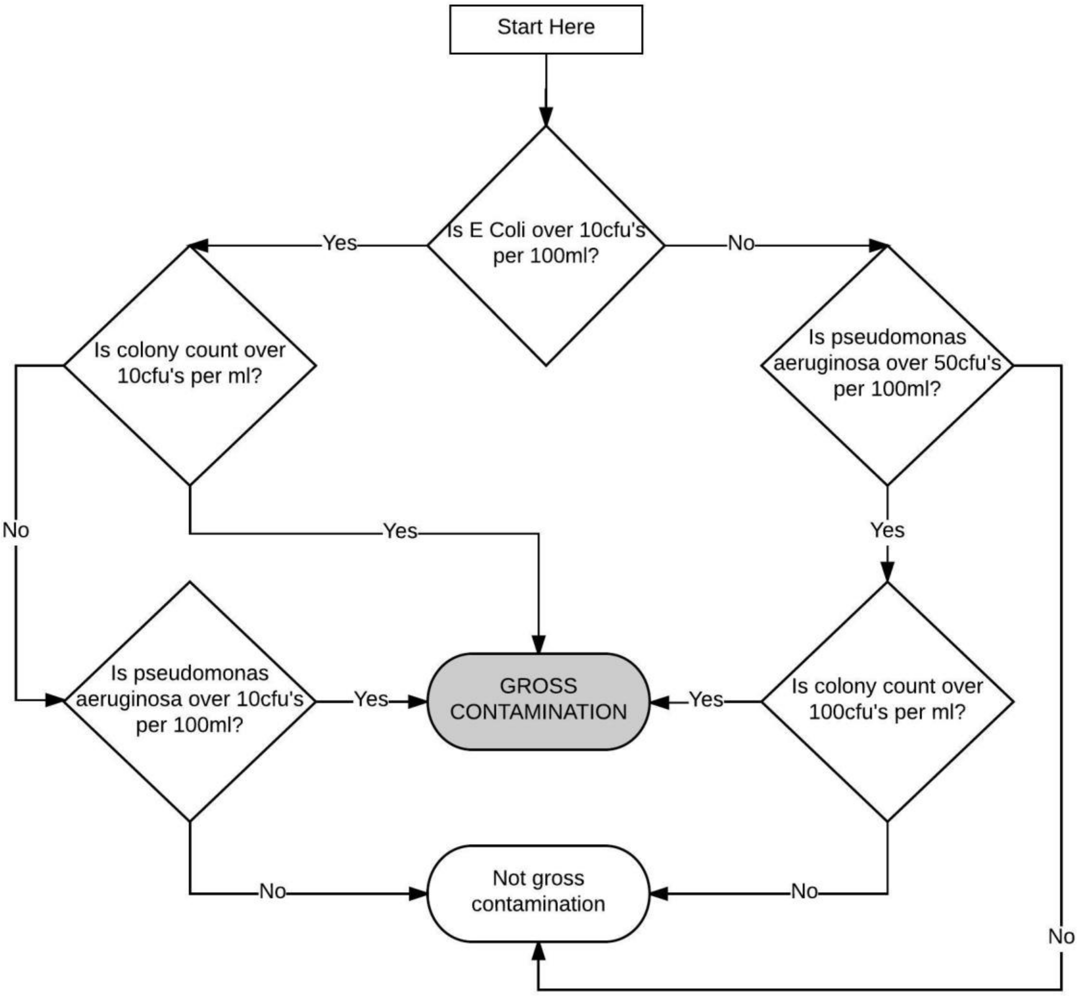
		will depend on bathing load).	excess bromine)	more disinfectant.
pH	7.2 – 7.4	Before opening and then every 2 hours during use (less if auto-monitored, but will depend on bathing load).	Add an acid (eg. Sodium bisulphate)	Add and alkali (eg. Sodium carbonate).
Total Dissolved Solids (TDS)	<1000 ppm above source TDS	Daily	Dilute (30 litres of fresh water, per bather, per day). Backwash the filters.	Not applicable – try and get it as low as possible.
Total Alkalinity	80 – 200 mg/l	Weekly	Dilute.	Add sodium bicarbonate.
Calcium Hardness	75 – 150 mg/l	Weekly	Dilute.	Add calcium chloride.
Water Balance (langelier index)	+ 0.1 - + 0.4	Weekly	Depends – various factors may need correction.	Depends – various factors may need correction.
Cyanuric Acid (if using stabilised chlorine)	50 – 100 mg/l	Weekly	Dilute.	Add cyanuric acid.

Appendix 4: Swimming 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)																												
Langelelier index																												

Appendix 5: Gross Microbiological Contamination Flow Chart



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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
23 Townfields
Knutsford
Cheshire
WA16 8DR

To be returned by no later than 1 month following the last day of the course.

We strongly advise keeping a copy of the portfolio for your records.

All work **MUST BE YOUR OWN**.

Water Testing

The candidate should perform the full set of tests listed below and record the results onto the log sheet in use at the facility. The candidate must then sign below, along with an authorised counter signatory (e.g. line manager etc, but not a fellow course attendee), who must sign only once they are satisfied that the pool tests have been carried out to the required standard.

It is preferable that the counter signatory is a fully qualified, experienced Pool Plant Operator but if there is no such person, the counter signatory can be someone with legal responsibility for the pool, such as the centre manager, headteacher, hotel manager etc.

If there is no such counter signatory, you must record video evidence of pool tests being carried out and send the video file to: info@stockwellsafety.com

- Free chlorine
- Total chlorine
- pH
- Total alkalinity
- Calcium hardness
- Total dissolved solids

Candidate declaration

I am confident that I know how to carry out all the water tests referred to above and understand what the results mean.

Name: ______________________________ Signature: ___________________________

Counter signatory declaration

I am confident that the person listed above is competent to carry out water tests to the required standard.

Name: ______________________________ Signature: ___________________________

Job Title: ____________________________

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.

Backwash

The candidate must carry out a backwash procedure at their own pool, or at the training facility. This should be in accordance with normal operating procedures. It should include an explanation of why and when this must be carried out. The candidate must then sign below, along with an authorised counter signatory (e.g. line manager etc, but not a fellow course attendee), who must sign only once they are satisfied that the backwash has been carried out to the required standard.

It is preferable that the counter signatory is a fully qualified, experienced Pool Plant Operator but if there is no such person, the counter signatory can be someone with legal responsibility for the pool, such as the centre manager, headteacher, hotel manager etc.

If there is no such counter signatory, you must record video evidence of the backwash procedure being carried out and send the video file, along with your documented backwash procedure to: info@stockwellsafety.com

Candidate declaration

I am confident that I know how to carry a filter backwash and rinse procedure and have physically carried out the procedure several times.

Name: ______________________________ Signature: ____________________________

Counter signatory declaration

I am confident that the person listed above is competent to carry a filter backwash and rinse procedure to the required standard.

Name: ______________________________ Signature: ____________________________

Job Title: _____________________________

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 hazard classifications does the chemical have (i.e. corrosive, irritant, toxic etc.)?
What are the main routes of entry (i.e. inhalation, skin contact, ingestion)?

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.
List the current control measure that are 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 matrix on page 149.
What is the likelihood that harm will be caused? Again, use the risk rating matrix on page 149.
What is the overall risk rating? Multiply the above two numbers together.
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

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STOCKWELL SAFETY

NEBOSH National General Certificate in Occupational Health and Safety

IOSH Leading | Managing | Working Safely

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Manual Handling

DSE Assessments

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We also provide health and safety and leisure water treatment consultancy services

01565 650 549

info@stockwellsafety.com