Code of Practice

THE MANAGEMENT AND TREATMENT OF SWIMMING POOL WATER

Pool Water Treatment Advisory Group

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Code of Practice

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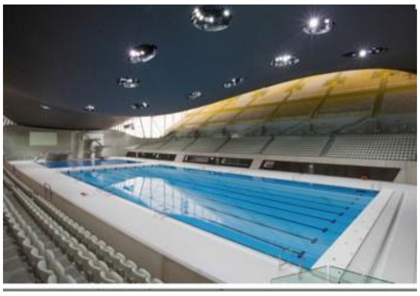


FOREWORD

This Code of Practice (CoP) has been prepared and published by the Pool Water Treatment Advisory Group (PWTAG), which retains its ownership and copyright. The CoP is based substantially on the book Swimming Pool Water: treatment and quality standards for pools and spas (PWTAG 2017), as updated by technical notes available from www.pwtag.org.uk.This latest edition incorporates the pool water treatment system requirements previously featured in the HSE document Managing Health and Safety in Swimming Pools (HSG179). And the update to HSG 179, the 4th Edition. The HSE says that it recognises PWTAG guidance as a useful resource for pool operators when drawing up their operating procedures. That, detailed technical guidance on types and efficacy of pool water treatment systems and associated risks is contained in the PWTAG Code of Practice and the Swimming Pool Water Book. And that, enforcing authorities (HSE and local authorities) consider this guidance as the standard to be achieved in effectively managed swimming pools.

This CoP provides for public swimming pools a practical summary of the recommendations and guidelines in the book, but also specific practices which pool operators can follow and against which their operation can be evaluated. It does not replace the book, which contains further practical detail and clarification.

1 SCOPE

This CoP contains general operational and safety recommendations for the management of public swimming pool water treatment systems and associated water treatment plant. The CoP sets out how the technical operation of the pool should function for safe, healthy, swimming pool water.

1.1) Why a code of practice?

The purpose of this CoP is to provide pool managers and operators with the fundamental principles of good practice in swimming pool water technical operation. Following it, pool staff should be able to provide a safe, enjoyable swimming experience for users as well as a safe operation for workers.

1.2) The main risk in swimming pool water treatment are health issues

- Water quality
- Chemical risks
- Physical risks (e.g. drowning, slips and trips, entrapment)
- Infection (e.g. Cryptosporidium, various bacteria and viruses causing gastroenteritis and Pseudomonas aeruginosa)

1.3) Potential risk to the individual

- Personal illness or death
- Long-term effects of illness
- Loss of employment, income, or educational opportunities
- Impoverished experience
- Increased costs
- Passing disease on to relations and friends and other swimmers

1.4) Potential risk to your organisation

- Damage to reputation
- Loss of income if visitors don't come because they perceive that the risk of harm is too great
- Civil claims arising from visitor illness, leading to financial loss
- Prosecution and penalties for breaches of criminal law
- Impact on the morale and esteem of employees

1.5) Good practice

This CoP focuses on good practice, based principally on published guidance from PWTAG, guidance to the industry from PWTAG that has been developed over many years. It also includes material from the Health and Safety Executive, Public Health England, Public Health Wales, Health Protection Scotland, the World Health Organisation and BS EN standards.

1.6) Standards of design and equipment

This CoP is based upon a pool designed in accordance with the guidelines detailed in *Swimming Pool Water*. Where pools have inappropriate design or inadequate specification, then providing a safe, quality swimming pool water will present a challenge, which ideally should be addressed prior to defining operational practices.

1.7) Types of pool covered by the code of practice:

This CoP covers swimming pools as defined in British and European standards:
1.4.1 Swimming pool type 1 – pools where the water-related activities are the main business (e.g. communal pools, leisure pools, water parks, aqua parks) and whose use is public
1.4.2 Swimming pool type 2 – pools which are additional services to the main business (e.g. school, hotel, camping, club, therapeutic) and whose use is public.

1.8) Types of pool not covered by the code of practice:

- Spa pools (covered by HSE guidance HSG282)
- Natural (green) bathing pools
- Interactive water features
- Paddling pools
- Domestic pools

However, many of the principles contained within the CoP can also be successfully applied in these types of premises. And they are specifically dealt with in *Swimming Pool Water*.

2 MANAGEMENT REQUIREMENTS

The pool operator has a general duty to set out a safety policy for the operation of the pool.

2.1) PSOP - Pool safety operational procedures

The recognised way to define a pool's safety policy is to establish and maintain pool safety operational procedures (PSOP). There should be two sections – normal operational plans (NOP) and emergency action plans (EAP). The PSOP should include management's assessment of hazards associated with all aspects of the pool – physical, risk of infections and supervisory – as well as a section on the technical operation of the pool, which features swimming pool water quality.

2.2) Pool technical operation procedures (PTOP)

This CoP requires pool management to define and document its policy and procedures for the general operation of the pool water treatment. This is called the pool technical operation procedures (PTOP). The PTOP forms a part of the risk assessment process for the whole pool facility and the subsequent formulation of pool safety operational procedures (PSOP). It should take the form of a stand-alone document detailing a swimming pool's technical operation, which is part of the PSOP. An example of a PTOP is given in the Appendix

The pool PTOP will be based on PWTAG published guidance, but more particularly the requirements of the suppliers, manufacturers and installers of plant and equipment. It will set out how the plant should function and be operated safely. Just as significantly, the PTOP for a pool will incorporate operational considerations that provide a healthy, enjoyable, satisfying and safe experience for users. The PTOP may use this CoP for its structure, supplemented or amended where appropriate to the individual circumstances of a pool.

2.3) Planning and organising

Preparing a PTOP demands planning the approach to pool water, ensuring that it integrates with other management activities.

2.4) Elements of an organisation's PTOP

Whatever the size of organisation and resources available, the first step is to establish a policy for water quality, safety, and hygiene and to have a strategy for its implementation. There should be clear objectives and a good management plan to achieve them. Learning from experience is important. You should review the outcomes and if necessary make changes to improve things.

2.5) Policy and planning

Developing a policy for water quality management and promoting a plan for its achievement will ensure effective use of the organisation's resources as well as ensuring bather safety.

An effective policy will:

- Demonstrate the commitment of senior management to the quality and safety of pool water
- Integrate the quality and safety of pool water management with other relevant organisational policies and management activities throughout the organisation.

An effective strategy will:

- Clearly set out how the organisation is structured to deal with the quality and safety of pool water issues
- Show how that organisation might usefully change, and set out the steps to get there
- Identify the resources, in money and staff time, necessary to achieve the objectives.

2.6) Planning and organizing

Develop plans for the management of the quality and safety of pool water at levels appropriate to the size and structure of the organisation. A large enterprise attracting hundreds of thousands of bathers each year would need a detailed PTOP. For a small pool open on a limited basis a much more basic document covering essentials would be sufficient. This code of practice contains the information necessary for producing such a document. An example of a PTOP is given in the Annex 17

2.7) Implementation and operation

The key to implementation and operation is defining clear roles and maintaining the awareness of those involved.

Define clear roles - State who is responsible for carrying out each task identified in the PTOP.

Awareness - Pool management should establish and maintain procedures in the PTOP to make staff and others involved aware of the importance of their roles and responsibilities in complying with the pool procedures, and with the requirements of the PTOP.

Performance monitoring - There should be a programme of inspection and clear records kept of the findings and actions. It helps to follow a written programme of priorities, keeping a record of what has been done, when, where and by whom, then listing work planned for the future. Management will then be able to demonstrate progress and ensure that the investigation and resolution of any outstanding issues is included in a work programme.

Learn from incidents and near misses - Incident and accident data are valuable indicators of risk and provide a measure of performance. Near misses should not be ignored; rather, staff should be encouraged to report them and treat them as an opportunity to learn from something that did not quite happen, this time.

2.8) Monitoring, analysis and improvement

As a minimum, pool management should monitor the safe and effective performance of their pool operation through the following:

- Plant and treatment systems logs
- Pool water testing
- Bacteriological monitoring and interpretation
- Feedback from regulatory authorities and users of the pool
- Actions taken or required to ensure compliance with operational plans and procedures
- Any corrective and preventive actions
- Responding to incidents and other emergencies
- Pursuit of the PWTAG Poolmark award and/or any other industry recognised awards.
- Staff training

2.9) Learning and improvement

Management should learn from the information gathered, in order to make improvements. Routine work should incorporate mechanisms that allow feedback to be used to improve services and safety, and to explain why no changes are being made.

2.10) Review against the written PTOP

Review is a key part of a management process. Decisions made as part of the monitoring, learning and improving processes should be checked at each stage to ensure they are consistent with guiding principles. Progress should be measured against plans, to identify problems and instigate any necessary corrective actions.

The water treatment system and the pool hall ventilation and heating should both be formally reviewed at planned intervals (at least annually) to ensure their continuing suitability and effectiveness. Ideally this should be prior to or during annual maintenance.

Input to the review should include assessing opportunities for improvement and the need for changes to the water treatment system, including the policy. Inputs to the management reviews should include:

- Feedback from bathers or other users of the pool, suppliers, regulators and other external parties on the performance of the water treatment system
- Action taken to restore or to improve water quality
- Incidents or emergencies impacting upon water quality
- Follow-up actions from previous management reviews
- External and environmental changes that could affect the water treatment system, including changes in pool plant or chemicals
- Changes in regulations or national standards including this CoP and

relevant BS EN standards.

2.11) Swimming pool technical staffing requirements

All pools should have some form of qualified staffed presence responsible for its technical operation. The type of cover depends on the type and use of the pool.

This CoP is based on the following model.

It is not the only model that could be used and the terminology can change but this model is written and designed to fit with the CoP

Either of the following staffing situations shall apply for all swimming pools:

1. On site Swimming Pool Technical Operators, or
2. Contracted visiting Swimming Pool Technical Operators

A Qualified Pool Technical Operator shall be on-site or immediately available within two hours during all hours of operation for pools covered by the CoP:
Included in these categories are:

- pools with more than 120m2 of water area
- pools with more than 120m3 of water volume
- pools with a throughput of an average of more than 200 bathers daily
- hydrotherapy pools
- pools used to provide swimming lessons and swimming training
- permanent school pools
- facilities used by the general public and children that include interactive water features.

2.12) Contracted visiting Swimming Pool Technical Operators

All other pool facilities shall either have, as above,
An on-site qualified Swimming Pool Technical Operator or immediately available within two hours or
A contract with a visiting Swimming Pool Technical Officer for a minimum of weekly visits and assistance whenever needed.

Visit Documentation
Written documentation of these visits for contracted visiting Swimming Pool Technical Officer visits and assistance consultations shall be available at the Swimming Pool for review by the management of the pool.

Documentation Details
The written documentation shall indicate the checking, monitoring, and testing outlined in PTOP.

Visit Corrective Actions
The written documentation shall indicate what corrective actions, if any, were taken by the contracted visiting Swimming Pool Technical Officer during the scheduled visits or assistance requests.

Onsite Responsible Supervisor
All Swimming Pools without a full time on-site qualified Swimming Pool Technical Officer shall have a Onsite Designated Supervisor

Onsite Designatee Supervisor Duties

The On-site Designated Supervisor shall:

1. Be capable of testing and recording the water quality parameters required by this Code of Practice;
2. Know how to make adjustments, as needed, to maintain required water quality parameters required by this Code of Practice;
3. Know general maintenance procedures as required by daily operational verifications or adjustments required by this Code of Practice;
4. Know when the Swimming Pool facility should be closed;
5. Know how and when to contact the contracted off-site Swimming Pool Technical Officer

Although not responsible for plant maintenance, the Onsite Designated Supervisor must be knowledgeable and competent on the operation of the facility in terms as required in the pool's PSOP for both normal and emergency action plans

The Contracted visiting Swimming Pool Technical Operator should provide regular (weekly minimum) visits and assistance whenever needed. Written documentation of these visits should be available at the facility. The written reports should at least show that:

- The circulation, filtration and disinfection systems were checked and working satisfactorily
- The safety equipment was noted as available on site and in working condition
- The pool and its infrastructure were in good condition
- Water chemistry and bacteriology were tested, their resulting values recorded on the report, and were found to comply with this CoP
- The operator took any corrective actions.

2.13) Staff Training in handling chemicals

Pool operators must provide information, training and instruction for employees who work with substances hazardous to health (www.hse.gov.uk/coshh/basics/training.htm). This includes qualified technical pool operators, general pool staff, lifeguards, or any others who are involved in the storage, use, or handling of chemicals. Training shall include:

Storage and Handling

Procedures for chemical storage and handling outlined in the PTOP and this Code of Practice.

Personal Protective Equipment Procedures

Standard precautions, PPE, and other measures to minimize exposure to chemicals as required by PTOP. This shall include staff training in PPE and respiratory protective devices when required.

Spill Procedures

Spill Procedures and Emergency Response outlined in the PTOP and this Code of Practice.

Safety Data Sheets
Know the chemicals used on site and were and how to access SDS.

Training Plan
Pool management/employers shall have a training plan in place and implement training for employees on chemicals used at the pool before their first exposure to hazardous chemicals and whenever a new hazard is introduced into the work area.

Training Topics
The training shall include at a minimum:
1. How to recognize and avoid chemical hazards;
2. The physical and health hazards of chemicals used at the facility;
3. How to detect the presence or release of a hazardous chemical;
4. Required PPE necessary to avoid the hazards;
5. Use of PPE;
6. Chemical spill response; and
7. How to read and understand the chemical labels or other forms of warning including SDS sheets.

Training Records
Records of all training shall be recorded and maintained on file.

2.14) Qualified technical operator qualifications and certificate

- This CoP is freely available in order that swimming pools can adopt it and follow it for safety and effective operation. Similarly, there is Training Syllabus freely available which complies with this Code of Practice upon which operators can base their training requirements
- Possessing an up-to-date qualification that complies with this CoP, is the best way to demonstrate to the enforcing authorities an acceptable level of knowledge and practical skills that are both suitable and sufficient
- A qualified technical operator should have completed a technical operator-training course that complies with this CoP. This should always be supplemented by on-site, specific training, with monitoring and assessment of competence.
- All operator-training courses should include as a minimum the learning elements detailed in the PWTAG CoP model syllabus (available from www.pwtag.org.uk).
- A qualified technical operator should have a current, in date certificate or written documentation showing satisfactory completion of a technical operator-training course.
- Originals or copies of such certificates or documentation should be available on site for inspection by the Environmental Health Officers/ Health and Safety Inspector for each qualified operator employed at or contracted by the site, as specified in this CoP. Originals should be made available upon request by the relevant authority.

2.15) PTOP; system documentation (an example of a PTOP is given in Annexe 17)

The PTOP should be maintained in paper or electronic form and should contain or refer to the following:

- An organisation chart showing lines of authority, responsibility and allocation of functions stemming from senior management, and contact details
- The normal operational plan covering the operation and safety of the water treatment and heating and ventilation systems
- The emergency action plan
- A current schematic drawing showing the swimming pool, plant and associated pipework
- Procedures covering the identification of noncompliance against clauses of this CoP and action to be taken to resolve such issues.

Records

The pool management must ensure the effective implementation of all documented procedures and instructions and these must be recorded. Records should be maintained to chronicle the technical operation of the pool and plant.

It is important that records demonstrate that:

- Procedures have been effectively used and implemented
- There is compliance with the relevant clauses of this CoP
- Where compliance with clauses cannot be met, appropriate risk assessment methods have been applied to determine the safety of the system
- Appropriate means have been applied to ensure identified risks have been minimised and are within established safety limits
- Relevant, adequate qualifications and training has been provided for all staff involved in the safety and operation of water treatment, heating and ventilation systems

Records should be kept so that continued confidence may be demonstrated for a period of at least five years.

3 WATER TREATMENT

The effective technical operation and safety in any swimming pool starts with careful planning, specification and design. The specific sources of information from which the technical design and operational standards recommended for swimming pools can be obtained are:

- BS EN standards 15288-1 Safety requirements for design
- BS EN standards 15288-2 Safety requirements for operation
- PWTAG Swimming Pool Water: treatment and quality standards for pools and spas
- PWTAG online Technical notes
- Sport England Swimming Pools Design Guidance Note.

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

Water treatment systems are an integral part of the architectural, structural and mechanical design of a swimming pool. The design, selection and operation of water treatment plant has to take into account:

- Public health hazards
- Mains water quality and storage, dilution and drainage, coagulation, filtration and disinfection
- The size and type of pool, bathing load, circulation rate, circulation hydraulics and turnover period
- Pool operation, water treatment system and plant room.

3.1) Public health hazards

Within a pool facility there are many potential uses of water where users and those in the vicinity may be exposed to hazards with the potential to cause injury and waterborne illness. Examples include:

- Death through drowning, including hair and limb entrapment
- Neck and head injuries from diving into shallow water or hitting other swimmers
- Injury from falls, slipping, etc.
- Potential drowning where cloudy water prevents surveillance of swimmers under the water
- Cuts and abrasions due to sharp edges, cracked tiles etc.
- Ingestion of pool water containing pathogens (microorganisms causing illness) including the protozoal parasites Cryptosporidium and Giardia that can cause gastroenteritis
- Contact with contaminated water, especially in contact with open wounds
- Inhalation of aerosols containing hazards e.g. Legionella species in distributed water, such as when using showers, but also from water jets and

indoor fountains
- Skin infections of the feet, including warts, verruca's and athlete's foot; some from pool floats and toys
- Possible exacerbation of asthma due to excessive disinfection by-products in the air
- Adverse health effects from water contaminated by chemicals

3.2) Mains water quality

The water companies' treatment processes provide safe water but, especially if from a river or reservoir (surface waters), are likely to contain some or all of:

- Organic materials, including humic acid (a precursor of the undesirable chlorination by-products called trihalomethanes, which themselves may be present)
- Lime and other alkalis (added to prevent corrosion in the supply network)
- Phosphates (added to prevent lead and copper dissolving from pipework, but which encourage algal growth in the pool)
- Other substances at levels, which, if boosted by pool water treatments, may take the levels above, recommended limits.

So it is essential that there is careful control of a pool's disinfection, pH, alkalinity, calcium hardness, dissolved solids and filtration.

3.3) Source water monitoring

Pool plant treatment should be set up to take account of an analysis of all relevant source water parameters. The water should meet drinking water quality standards; this applies also to private water supplies. The disinfectant type should so far as practicable be compatible with the source water supply.

3.4) Primary disinfection

Disinfection means removing the risk of infection, and is achieved primarily by maintaining the correct concentration of disinfectant in the water. Primary disinfection will kill bacteria and viruses (and provide a residual to prevent cross-contamination); oxidation by disinfectants also breaks down soluble dirt and other organic contamination introduced by bathers.

At the same time other water quality parameters, in particular pH value, have to be kept at the correct value for disinfectant to act effectively and efficiently.

For disinfection to proceed freely, the water must be clear and free of suspended material, which may shelter the microorganisms from disinfectant activity. Effective filtration is key to this. Equally, the disinfectant has to be given time to kill. In general the efficiency of disinfection depends on the initial concentration of disinfectant and the contact time of the water with the disinfectant (exposure value or CT value) and the residual disinfectant concentration at the end of the contact time.
For example: Exposure value = Contact time x Free chlorine residual (at the end of the time).
If contact time is expressed in minutes and chlorine in mg/l, the unit of exposure value is mg.min/l.

Many disinfectants also oxidize waste matter, controlling the build-up of what is the food for many microorganisms (as well as a water contaminant in its own right) and helping maintain a fine sparkling water Mains water contains a small amount of such material, but the chief sources are introduced by bathers – sweat, skin particles, mucus and urine. Such bather pollution can and should be minimised by pre-swim hygiene.

Disinfection should extend beyond the pool water to the filters in the filter plant, as microorganisms often find excellent conditions for rapid reproduction in them, warmth, darkness, a bed of filter media, and a plentiful supply of food. Without adequate disinfection, filter beds may harbour pathogenic organisms including some amoebae, *Staphylococcus aureus* and *Pseudomonas aeruginosa*.

Dosing disinfectant before the filter prevents inadvertent mixing of disinfectants and acids (which are added post-filter). However there are arguments for dosing disinfectant post-filter; (this issue is dealt with in *Swimming Pool Water*). Secondary disinfection by ultraviolet (UV) radiation or ozone (which remove or reduce primary disinfectants), demands dosing disinfectant after the secondary treatment.

Automatic dosing (disinfectant and pH value kept to set limits in response to continual monitoring) is the preferred and usual method of applying disinfectant to the water and essential for public pools.

Electronic sensors monitor pH value and residual disinfectant value continuously and adjust the dosing correspondingly to maintain the previous set values in the pool water. But regular verification of the system (including manual tests on pool water samples), and good management of it, is still important. Manually operated and monitored dosing systems should also be backed up by good management of operation, monitoring and records. Dosing pumps should be designed to shut themselves off if the circulation system fails (though automatic water quality monitors should remain in operation).

3.5) Secondary disinfection

Secondary disinfection of pool water (UV or ozone) increases the kill of infectious organisms, especially the chlorine-resistant protozoan *Cryptosporidium*. Due to the risk of cryptosporidiosis 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 the reduction of troublesome, irritant chloramines and being able to have lower disinfectant residuals in the pool water. These systems will take the form of either UV or ozone and should be designed to provide an effect equivalent to achieving a 99% reduction in the number of infective *Cryptosporidium* oocysts per pass through the secondary disinfection system.

UV

UV should be applied to the full flow of water through the treatment plant and monitored to ensure an effective dose rate. A UV monitor on the chamber’s outer wall should warn if the dose transmitted through the water falls below the

prescribed level for any reason
UV systems intended for the control of chloramines as well as microorganisms should be equipped with medium-pressure lamps at 60mj/cm_2 (broad spectrum between 200 and 320nm).

Low-pressure lamps (254nm) are only biocidal, so they will deal with bacteria and *Cryptosporidium* but do not deal with di and tri-chloramines as effectively as medium-pressure UV.

The system should be designed to achieve a minimum 99% reduction in the number of infective *Cryptosporidium parvum oocysts* per pass through the UV system.
Satisfactory disinfection of UV systems should be demonstrated by third-party validation using the US recreational water standard NSF/ANSI 50, or other regulatory standards confirming 3-log reduction in the viability of Cryptosporidium parvum oocysts. Dose values should be guaranteed by manufacturers throughout the life of the lamp.

Ozone

Ozone should also 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 1mg/l in water circulated.
Ozone is a toxic gas more stable in air than in water. Concentrations of 10mg/m3 in air lead to serious irritation and breathing difficulties. The threshold limiting value is 0.2mg/m3. Although ozone has a distinctive smell the nose is not a reliable guide for this. So it is important that the ozone generation system fails safe and gives adequate warning on failure.

3.6) Dilution with fresh water

Disinfection and filtration will not remove all pollutants. UV and ozone will greatly improve removal but some pollution can be reduced only by dilution of the pool water with fresh potable water. This should also limit the build-up of pollutants from bathers and elsewhere, the byproducts of disinfection, and various other dissolved chemicals.

If dilution is inadequate, bather discomfort in the form of chlorinous, irritant gasses can result. Pool operators should be prepared to replace pool water with fresh water as a regular part of their water treatment regime at a rate of 30 litres per bather. The water that is replaced in the backwashing of filters contributes significantly to this requirement.

Dilution rates should be monitored and adjusted according to pool bather usage.

3.7) Bathing load

The maximum bathing load (number of bathers) allowed for at any one time determines the circulation rate, turnover, treatment plant size and other parameters. This bathing load should have been determined at the design stage for the pool. The maximum bathing load takes into account:

- The surface area of water in the pool

- The water depth
- The type of bathing activity the pool is intended for

The maximum bathing load for each pool must be defined in the PSOP and pool managers shall provide systems controlling entrance to the pool or provide other means of monitoring to ensure that the maximum bathing load is not exceeded.

The starting point for calculating bathing load is the maximum loading of a pool for physical safety: 1 bather per 3m2.

The maximum bathing load should also take into account the capacity of the water treatment plant, using the ratios in Table 1.

Table 1:

Water depth	Maximum bathing load
< 1.0m	1 bather per 2.2m2
1.0 m to 1.5m	1 bather per 2.7m2
> 1.5m	1 bather per 4.0m2

The operational daily bathing load should be reviewed regularly to determine whether the treatment system is capable of maintaining good water quality. It should be established using this formula:
Operational daily bathing load = 25 to 50% of maximum bathing load x number of hours use per day

The operational daily bathing load for each pool should be recorded, including details of the basis on which it was calculated. If the operational daily bathing load is approached or exceeded frequently, then attention may need to be given to:

- Increasing the treatment plant capability
- Additional dilution of the pool water with fresh water
- The use of secondary disinfection – UV or ozone.

3.8) Circulation rate

The circulation rate should be derived from this formula: Circulation rate (m3/h) = Maximum bathing load x 1.7
The circulation rate and turnover period are related and form the basis for sizing new water treatment plants, and for checking the capacity of existing water treatment plants.

3.9) Turnover period

The turnover period should be calculated from this formula:

$$\text{Turnover period (h)} = \frac{\text{Water volume (m}^3\text{)}}{\text{Circulation rate (m}^3\text{/h)}}$$

3.10) Pool type and turnover

Different sized pools and pools of different types should have turnover periods in accordance with Table 2.

Table 2: Turnover periods for different types of pool

Turnover periods for different types of pool

3-4h Competition pools 50m long

4-8h Diving pools

4-8h Domestic pools

30-90min Hydrotherapy pools

20min Interactive water features

5-20min Leisure water bubble pools

10-45min Leisure waters up to 0.5m deep

30-75min Leisure waters 0.5-1m deep

1-2h Leisure waters 1-1.5m deep

2-2.5h Leisure waters over 1.5m deep

2.5-3h Public pools up to 25m long, 1m shallow end

6min Spas – commercial

15min Spas – domestic

30-90min Teacher/learner/training pools

30-60min Waterslide splash pools

Maximum bathing load

If the turnover period calculated for an existing pool is longer than the values in Table 2, the maximum bathing load should be reduced using this formula:

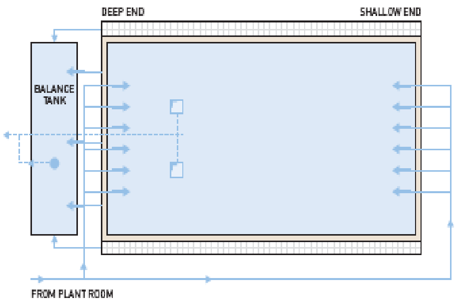
$$\text{Maximum bathing load} = \frac{\text{Water volume } (m^3)}{\text{Turnover period (h)} \times 1.7}$$

The turnover period of pools with moveable floors should be appropriate to the pool at its shallowest point (ie potentially biggest bathing load).
The pool hydraulics should ensure appropriate turnover periods and good mixing of water in the pool; short circuits and dead legs should be avoided.

3.11) Dye testing

All pools should be dye tested when first commissioned, to prove the circulation and flow works as specified; and thereafter if there has been remedial work or if there is a circulation problem affecting water quality. See BS EN 15288 1 & 2 and Annex C.

4 POOL ESSENTIALS



Pool water should circulate 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.

4.1) Surface water removal

Some unsightly, unhealthy matter remains on the surface of the pool water, and the majority of the organic pollution and contamination is concentrated at or near the surface irrespective of the mixing effects of the circulation system. This is also a source of potential infection. So the recommendation for a really healthy and attractive pool, is surface water removal of between 80 and 100%. Achieving over 80% of circulation flow from the pool's surface demands a deck-level pool with balance tank.

Outlet and inlet safety

The safety of pool outlets and inlets is a critical issue. Of course, their covers and grilles should be strong and secure enough to withstand any likely impact or vandalism. And apertures should not have gaps over 8mm, so fingers and toes cannot get caught in them. But there are more detailed design and hydraulic issues that are crucially important. See BS EN 13451-1:2011+A1:2016

Outlet specification

Water velocity through outlets should not exceed 0.5m/s. When calculating the size of outlets to achieve this, the free open area of the grille should be taken into account. This typically varies between 30 and 40% of the overall size of the grille.

To avoid the risk of a vacuum trapping a bather on an outlet, all suction pipes that are capable of being connected to the full suction force of the pump system should be connected to at least two separate outlets at least 2m apart and preferably at least 2m from the side walls (to avoid impact from jumping bathers).

The principle is that a single bather should not be able to block all the outlets to one suction pipe.

The outlet piping should be hydraulically balanced and the suction pipes carefully sized and located in relation to the outlet covers.

The system should give uniform flow through the outlet covers without localised high velocities or streaming.

On existing pools with only one outlet, there are a number of options.

- A larger grille can be fitted to the outlet. It should conform to the safety principles described here, only single grilles with a surface of the area circumscribed to the suction openings ≥ 1 m2 are allowed, or supplementary requirements of BS EN 13451 – 3 should be followed
- Extra sidewall outlets may be fitted as close as possible to the pool base

and sized to meet the maximum velocity requirement above.

Inlets
Inlets delivering water to the pool should be arranged so as to ensure that each takes its required proportion of flow. Where possible they should not stand proud of the wall or floor surfaces, or have any sharp contours. There should be enough inlets to ensure that there is adequate mixing and distribution within the pool (without streaming) and that the velocity of the water entering the pool does not generally exceed 1.5-2m/s, and perhaps as low as 0.5m/s in shallow or sensitive areas (steps, teaching points etc) where turbulence might be a problem or where base inlets are involved.

Water features like geysers, waterfalls, jets and sprays demand a far higher inlet water velocity to achieve the desired effect. It is essential, then, that safety in relation to location etc is fully assessed. The same careful consideration should be given to inlets in pools for children and toddlers.

Circulation pipework
Pipework systems should be sized to limit water velocities below levels that cause excessive headloss due to friction. Friction increases energy consumption and reduces the life of valves, strainer boxes etc. Velocities can be slightly higher in the delivery pipework than in the suction pipework – though the resulting increase in headloss within the system should be taken into account when sizing the circulation pumps.

As a guide that conforms to good engineering practice, pipe velocities should be:
- suction 1.5m/sec
- delivery 2-2.5m/sec.

Circulation pumps
Pools should have sufficient pump volume/ head capacity to achieve the required pool turnover period even as the filters become dirty. Standby pumping capacity should be provided in a public pool to allow the plant to continue to function at full flow if one of the pumps has failed. The pumping system should be capable of reduced flow rates at night when appropriate. Three half-capacity pumps provide flexibility: motors and pumps can be rested in rotation, and turnover and energy use can be reduced during closed periods, without compromising water quality. Variable speed drives can be used to control pump flow efficiently (See Swimming Pool Water on how)

With all pools, it is vital that the circulation rates for specified turnover periods should be maintained by the pump (or pumps) when the filters are dirty (offering the maximum resistance in the system) and taking into account any extra processes such as water features, UV and ozone

Instrumentation
All pools should have sufficient instrumentation to measure the performance of the system including:
- a flow meter fitted after the circulation pump and before the filters to measure the circulation rate and the backwash flow rate for each filter
- inlet and outlet (or differential pressure) gauges on each filter to measure

the headloss across the filter bed
- a water meter on the makeup water system, which gives a measure of dilution
- Ultrasonic flow meters with remote indicators are the easiest to manage

5 FILTRATION

Effective filtration is the primary mechanism for ensuring water clarity. Clarity of pool water is critical. It should be possible to see clearly the detail of the bottom of the pool at its deepest point. If not, there is an immediate physical danger to anyone in distress, as well as the likelihood of discomfort to bathers because of the poor condition of the water. Also, disinfection will be compromised by reduced clarity.

Clarity is reduced by turbidity – colloidal or particulate matter in suspension in the water. It is important to know the source of 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 appropriate disinfection coupled with coagulation (flocculation) to convert the colloids into a filterable flocculus, or floc.

Turbidity in a swimming pool is measured in nephelometric turbidity units (NTU). The generally accepted maximum value in swimming pools is 0.5NTU.

An effective filtration system including coagulation will also remove more than 90% of *Cryptosporidium* oocysts in a single pass of water-containing oocysts through the filter bed. It is an important function as these oocysts are much more resistant to disinfection than bacteria and viruses.

This CoP specifies filtration standards in terms of medium-rate filters using granular filter media, typically sand. This is a tried and tested method. There are filters that operate at higher rates, some with other media, some applying different filtration principles. These may be able to filter satisfactorily in some conditions, but operators should understand the potential disadvantages and be satisfied that they produce good clarity in the pool. Membrane and ultrafiltration systems are equally suitable and do not require the use of coagulant.

There are many pools in the public sector, where bather loads are not as high or as critical as public community pools (e.g. health clubs, hotels, schools) that use high-rate filtration – over 25 and up to 50 metres per hour. High-rate filters do not filter as well as medium-rate filters. Tests have shown they are about 10 to 25% as effective as medium rate. Accordingly, in these situations the bather loading should reflect the relative inefficiency of these filters (given that turnover and circulation are similar to pools with medium rate filters). Their use should be subject to a risk assessment.

5.1) Filters and filtration rate

In general, the greater the filtration velocity, the lower the filtration efficiency. In practice, efficiency falls off even more rapidly at velocities of over 25m/h (mÑ/mÇ/h). This can be demonstrated experimentally, using standard water tests for pollution.

Filter ratings are based on sand filtration rates. The three categories are ranges only:

- low-rate up to 10m/h
- medium-rate 10 to 25m/h
- high-rate 25 to 50m/h.

The loss of pressure through the filter is directly proportional to filtration velocity within the range of 10-25m/h. So, for conventional public pools where bathing loads are consistently high, a medium filtration rate of 10-25m/h is recommended. The filtration system should be based on the design maximum bathing load, operating 24h a day, ideally designed so that the circulation rate can be reduced overnight or during quieter periods.

If the filtration rate is reduced overnight, the rate should be increased again slowly. Sudden increases can detach deposits within the filter bed and result in material getting into the pool. If rate reduction has been achieved by shutting down one or more circulation pumps, it is essential to restart each pump against a closed valve, then slowly open the valve to achieve the desired flow rate.

Variable speed pumps save energy, but should be used only where the pool is working satisfactorily and does not need normal filtration rates for overnight recovery.

5.2) Filter beds

Filters may be either single or multi-grade type. For single-grade filters the sand bed should be a minimum of 800mm deep; for multi-grade filters the sand bed should be a minimum 550mm deep supported on a bed of coarser material 250mm deep.

Other filtration methods

There are alternatives to sand filtration: (See Swimming Pool Water and the PWTAG Technical notes)

5.3) Serviceable filters

Every filter should be designed to be serviceable. They should have:

- An automatic air eliminator and a safe, manually operated quick air release mechanism should be fitted to each filter.
- To measure the differential pressure across filter beds during operation, gauges should be fitted (and serviced as necessary) which indicate the pressure at the top and bottom of the filters.
- A flow meter should be fitted between pump(s) and filter (and regularly serviced) to indicate normal water flow and backwash rates. They need to be easy to read.
- The system should be capable of providing a backwash flow of a rate

and duration to suit the manufacturer's recommendation, which can also include the requirement of an air scour.

- The backwash water flow rate should not be less than the rate necessary for the fluidisation of the filter bed as specified by the manufacturer.
- Provision should be made for a backwash drain of an appropriate capacity.
- It should be possible to observe the clarity of the effluent water throughout the period of the filter backwashing. Normally a visual method, such as full-bore illumination of the backwash water outlet pipe or a branched sight glass, will be installed.
- The provision of one or two viewing ports (usually acrylic windows) on the filter will allow backwashing to be observed. An internal light is useful, especially with larger filters.
- Where it is going to be necessary for operators to enter the filter, there should be two access manholes – one on the top, one on the side towards the bottom – of at least 575-600mm diameter. Pressure Vessel and Confined Space regulations should be followed.
- Filter media can be removed using a vacuum system.
- Provision should be made, especially in large filters, for air scour.

Maintenance

- Filters should be opened up and inspected internally at least once a year by someone familiar with the sort of problems that can appear. That means attention to media quality, underdrains and corrosion. Unusual signs – fissures, an uneven bed, mud balling etc – need investigation. Any remedial work will need to be done by specialist contractors, perhaps under a maintenance contract.
- The filter lining may need to be replaced every 5-10 years. Filter media may also need to be topped up and perhaps replaced at the same sort of interval. Nozzles etc can be inspected when the filter is empty of sand, and may need to be replaced then.
- Daily records of flow rates, pressure differentials and backwash procedures should be kept.

5.4) Backwashing

- Backwashing sand filters is critically important for good filtration.
- A 5-6 minute wash may clean the bed adequately, but a viewing window (sight glass) on the filter outlet is the only way to check progress.
- Backwashing should continue for at least 6 minutes or until the backwash water is clear, whichever is the longer. The manufacturer's recommendations should also be taken into account.
- After backwashing, the normal flow should be restarted, but the filter should run to waste for a few minutes, which allows the newly expanded filter bed to settle, and dirt in the pipework to drain off.
- The backwash flow rate should be fast enough to fluidise the bed. For the sand grain size traditionally used in the UK (0.5-1mm) a flow rate of 30m/h is generally required
- Different filter media need different backwash rates. The choice of medium must match the filter so that the medium does not expand above the overflow level.

- Air scouring first – at about 32m/h at 0.35bar – can help clean the media.
- A viewing port (window) to show the top of the filter bed will allow operators to check fluidisation is achieved.
- The backwash water pipework should be large enough to discharge the water without a build-up of pressure inside the filter tank.
- Backwash lines should be sized and routed so that water can flow freely to drain without water becoming trapped and stagnating. So pipelines should not be routed upwards or overhead.
- The drainage system needs to accommodate both the backwash flow and the volume of backwash water discharged.
- The backwash drains should be adequate for the volume and velocity of backwash water. If the drainage system cannot deal with the backwash flow rate, a backwash water attenuation (holding) tank may have to be installed. An attenuation tank may also be necessary if the backwash water has to be dechlorinated before release.
- Backwash water from commercial pools and spa pools is classified as a trade effluent. Consent has to be sought from the relevant water authorities about the nature, volume and frequency of the discharge from backwashing and dilution.

When to backwash

- Backwashing should be done – at the end of the bathing day if possible – whenever the loss of pressure across the filter reaches the level recommended by the filter manufacturer; but certainly at least once a week.
- Filters should also be backwashed if the circulation has had to be stopped because of a failure or for maintenance.
- Even if care is taken not to reduce significantly the depth of the water in the pool, backwashing should not be done during bathing: active disinfection will stop during backwash, and some leisure areas may drain altogether. Also, there is an infection risk.
- After backwash, the first few minutes of flow should run to waste, not return to the pool. Thus, the dirty backwash water is flushed from the system.
- A just-backwashed filter benefits from a further ripening period (as the sand settles and returns to full working efficiency) of between 30 and 120 minutes. So backwashing at the end of the bathing day is good practice. This allows the filter to return to optimum efficiency when there are no bathers in the pool
- Commercial spa pools' filters should normally be backwashed daily. There should be sufficient capacity in the spa pool and the balance tank for backwashing the filter efficiently. Sufficient time should be factored into the process to enable the filter medium to settle prior to reopening the spa pool.

5.5) Coagulation

Coagulants (sometimes called flocculants) enhance the removal of dissolved, colloidal and suspended material by bringing it out of solution or suspension as solids (coagulation), then attracting the solids together (flocculation), producing a flocculus (floc) which is more easily trapped in a filter.

Coagulants help gather up bacteria generally, but are particularly crucial in helping filter three classes of material which otherwise would pass through the filter:

- the infective cysts of Cryptosporidium and Giardia – small and resistant to disinfectant
- humic acid – naturally found in some mains water and a significant precursor of unwelcome trihalomethanes
- phosphates in mains water and in some pool chemicals.

A coagulant should be dosed continuously and precisely, by chemical dosing pumps. Continuous low-level dosing of a coagulant is recommended for all pools (except those with membrane and ultrafiltration systems) to improve the filtration efficiency and increase the removal of any contaminants from the pool. This procedure significantly reduces the risk associated with any unseen faecal release.

- The recommended coagulant is polyaluminium chloride (PAC).
- PAC should be dosed as far upstream of the filters as possible, but after the chemical controller's sample point.
- PAC is directly and continuously dosed from the containers in which it is delivered. The dose rate as aluminium is about 0.1ml/m3 of the pool circulation rate.
- A peristaltic dosing pump is the most suitable type and should be capable of dosing accurately
- The small quantities required, and also of adjustment to the requirements of the bathing load.
- Coagulants should not be dosed by hand (unless specifically designed for this purpose) or via the strainer box.

6 DISINFECTION

A wide range of disinfectants is available commercially. This CoP uses hypochlorite as a model for disinfection procedures. This is the commonest disinfectant, especially in public pools. But the CoP does not intend to rule out the use of other effective disinfectant systems, including those that may be developed in the future. The choice of disinfectant should take into account:

- Safety – by using only chemicals listed in Swimming pool water: treatment and quality standards for pools and spas)
- Compatibility with the source water supply – using an alkaline disinfectant, eg sodium or calcium hypochlorite with soft water (water low in calcium and magnesium ions); an acid disinfectant with hard water (helps disinfection and demands less use of other chemicals like pH adjusters)
- Type and size of pool – inorganic chlorine-based disinfectants are good choices for public pools, with the additional use of UV or ozone for better quality of water. Alternative forms of chemicals such as trichloroisocyanuric acid (trichlor) may be more appropriate to less demanding pools and outdoor pools where the addition of cyanuric acid will help to prevent depletion of chlorine due to sunlight. (Note: cyanuric acid may interfere with automatic controllers)
- Bathing load – if the bathing load is frequently high, and excessive combined chlorine is a problem, secondary disinfection UV or ozone is useful in limiting chloramines as well as dealing with the threat from Cryptosporidium
- pH value - For chlorine disinfectants to work properly, the pH value of the swimming pool water is critical. Each 0.5 increase in pH value roughly doubles the chlorine residual needed to maintain the same level of disinfection. (At pH 7.5 a free chlorine of 1.0mg/l is 50% effective, i.e. equivalent to a free active chlorine level of 0.5 mg/l.)
- It is recommended that the pH value should be maintained between 7.2 and 7.4, as disinfection will be more effective
- Dosing with an acid is normally required with hypochlorites, in order to counteract their tendency to drive up the pH value. It is recommended that automatic dosing by pumps linked to a pH controller should be used if possible if manually controlled dosing pumps are used, they should be carefully controlled by pool operators, and monitoring of pH values should be every two hours
- In waters with a low natural alkalinity (maximum alkalinity of 150mg/l as CaCO3, maximum hardness 300mg/l as CaCO3) carbon dioxide (CO2) is usually preferred for pH reduction. Above those figures, CO2 is unsuitable: sodium bisulphate or hydrochloric acid (less than 18% to prevent corrosion in the plant room) are the norm for waters with high alkalinity and hardness. Sodium bisulphate will raise the sulphate concentration in the pool – see

page 129 – and should be used only in pools with sulphate-resistant cement

- Sulphuric acid will also raise sulphate concentration, and is recommended only at low strengths for safety reasons (see Technical notes 3 Sulphate Attack and 40 Choosing a pH correctant)

6.1) Sodium hypochlorite

Sodium hypochlorite is a liquid supplied with a maximum strength of 15% weight for weight as available chlorine. It is widely used in all types of pool. If accidentally mixed with acid, it releases chlorine gas.

See later section on Chemical Dosing for use

Sodium hypochlorite can also be generated hydrolytically by passing an electric current through sodium chloride (common salt) solution

6.2) Calcium hypochlorite

Comes in sealed plastic drums, as granules or tablets of different shapes or sizes, sometimes with scale inhibitor. Automated transfer and mixing systems that minimise handling, and thus exposure of operatives to the chemical, are safer than those requiring manual mixing of the granules or tablets in day tanks. But in practice the regular cleaning needed, and other maintenance problems, can cancel out that advantage with some dosing equipment.

Calcium hypochlorite is normally supplied in a hydrated form with typically 65-68% available chlorine. There is also a 78% hydrated granular material now available that, unlike some of the 65% hydrated products, is quick dissolving. The 73% anhydrous form should not be used in swimming pools on safety grounds. Calcium hypochlorite has up to 5% insolubles.

Calcium hypochlorite has three specific hazards:
It reacts violently with organic materials (chlorinated isocyanurates, some cleaning materials, even sugary drinks) by spontaneous combustion, explosion and the production of toxic gases. Even a trace of, say, oil can be enough. There can be similar consequences if it is used alongside chlorinated isocyanurates (sometimes unfortunately described also just as ‘chlorine granules’ or ‘chlorine tablets’). Like sodium hypochlorite, it reacts dangerously with acids. So staff should be aware that it needs to be stored, handled and used with care.

The granular form in particular can produce irritant dust that may affect the lungs quite severely. There are de-dusted versions. Even with tablet forms, personal protection equipment should be used.

If heated, it releases chlorine gas. It also supports combustion and can react explosively.

See later section on Chemical Dosing for use

6.3) Chlorinated isocyanurates

Chlorinated isocyanurates are white or off-white granules or tablets with a chlorine odour, stable when dry but in contact with water slowly liberating chlorine. Confusion with other white chemicals must be guarded against. 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. Cyanuric acid is a byproduct released into the water from dichlor and trichlor. Cyanuric acid makes the chlorine more stable in the presence of sunlight. For every mg of chlorine released almost as much cyanuric acid is added and accumulates in the pool water ultimately making the chlorine ineffective. To prevent this the cyanuric acid content must be diluted by the addition of fresh water.

6.4) Bromochlorodimethylhydantoin

BCDMH is an organic compound that disinfects with a free bromine residual. It comes in granules and tablets. BCDMH is relatively innocuous in storage, easy to dose, and often does not need pH correction. It is widely used in spa pools and indoor domestic pools, although there is an indication that spa pools using it are more likely to give unsatisfactory microbiological test results. There have also been reports in medical journals of skin irritation (itch and rash) of a type not found in chlorine pools. The decision to use it certainly does mean extra vigilance in being alert to reports of skin irritation, as well as operating to the guidelines in this book and from the manufacturer.

6.5) Sodium bromide plus hypochlorite

This is a proprietary system that involves the conversion of bromide to free bromine residual by the reaction of sodium bromide solution with a chlorine donor. The bromide level has to be checked and maintained, for the bromine disinfection to work, without any troublesome byproducts. The major irritant byproduct of chlorination, nitrogen trichloride, is not produced. As a result sodium bromide is used mainly in heavily bathed, large leisure pools where chlorinous disinfection has produced high levels of combined chlorines , and where there may have been corrosion of stainless and other steels.

6.6) Chlorine gas

Liquefied chlorine gas is the most concentrated form of chlorine disinfectant – the benchmark against which are measured the replacements that resulted from the government's 1978 recommendation to discontinue its use in swimming pools because of the danger of gassing accidents. It contributes less to total dissolved solids (TDS) in pool water than solid and liquid chlorine donors. Swimming Pool Water gives details of how chlorine gas may be effectively and safely dosed, delivered, and stored. But even the system now recommended – a separate, totally enclosed store with a fail-safe dosing system – has the potential, given operator error, of a life-threatening accident. Nevertheless, chlorine gas has demonstrated its ability to work well in recent installations, where all relevant precautions are taken, and the necessary approvals granted.

6.7) Ultraviolet radiation

Ultraviolet radiation is a secondary disinfection process (used alongside a

primary disinfectant, usually chlorine).
It is recommended by PWTAG, both for its capacity to reduce chloramines and kill microorganisms – including chlorine-resistant *Cryptosporidium*. Its use can reduce the chlorine residual levels necessary to keep pool water healthy. It is increasingly used as an alternative to ozone (which similarly complements chlorination) as it is easier and cheaper to fit, especially to existing plant.

- The UV system should be designed to treat the full water flow through the pool circulation system.
- If the system is to be selected on the basis of an assumed UV transmittance (UVT) that assumed value should be no greater than 94%, measured with 254nm UV light in a 1cm cell.
- UV systems intended for the control of chloramines as well as microorganisms shall be equipped with medium-pressure lamps (broad spectrum between 200 and 320nm).
- Low-pressure lamps (254nm only) are biocidal, but do not deal directly with di and tri-chloramines to the same extent that medium-pressure lamps do. They use less power than medium-pressure lamps but their lower output means that more lamps are needed. They have a larger footprint.
- The system should be designed to achieve a minimum 3-log (99.9%) reduction in the number of infective Cryptosporidium parvum oocysts per pass through the UV system (see D3).
- UV systems should be third-party validated.
- The UV equipment should be provided with calibrated UV intensity sensors, which measure the output of all the UV lamps installed in a system. Where multiple lamps are fitted, sufficient sensors should be provided to monitor all lamps. Sensors should be checked every six months and re-calibrated annually.
- The UV equipment should be able to display UV dose, expressed in units of energy per unit area.
- The chamber and all its components should be designed to withstand a maximum operating temperature of 40°C, but also occasional brief temperatures as high as 60°C.
- UV chambers should be fitted with high purity quartz sleeves/ thimbles (which can be doped) to separate the water passing through the chamber from the UV source.
- The UV system should be designed to permit cleaning of the quartz sleeves/thimbles without mechanical disassembly. The cleaning system should preferably be an automatic one; if a manual system is selected (perhaps for a lightly-used pool) it must be operated at least twice daily.
- A drain and vent should be provided on the chamber, which should be designed so that at least one end can be dismantled for general and physical cleaning.

Installation

- The UV system should be installed post-filtration, but before the heat exchanger, pH correction and residual chlorine dosing points.
- A by-pass should be provided to allow continuous pool operation during maintenance of the UV system.

- A strainer should be fitted downstream of the UV system to prevent any quartz shards entering the pool in the event of accidental breakage of the quartz sleeve.
- The aperture size of the strainer shall be no more than 1mm.
- Pipework adjacent to the UV unit should be of a suitable material.

Control requirements

- UV can affect THM production both ways, depending on local factors, but it is generally accepted that the effect is in practice neutral – as long as the UV is not over-dosed. To prevent this, UV systems may be equipped with variable power controls.
- Higher than necessary residual chlorine levels can also contribute to disinfection byproducts. Levels of between 0.5 and 2ppm should be sufficient with a UV system. Residual chlorine should be regulated amperometrically; if redox is used, it should be noted that UV does not oxidise.
- Medium-pressure UV lamps can be driven by an energy efficient electronic power supply. These can provide infinitely variable power adjustment to the lamp, giving precise control of dose, minimising power consumption and prolonging lamp life.
- UV systems should provide a readout of UV dose, UV intensity and flow rate.

(See PWTAG Technical Note 31 Ultraviolet disinfection: specification, maintenance and validation)

6.8) Ozone

Ozone gas can be generated in the plant room and used as a secondary disinfectant. HSE publishes guidance on the safe use of this toxic gas. This includes automatic alarms and shut down in the event of plant failure or indications from leak detectors.

Ozone contact system

- The ozone should be mixed with the whole body of water, because of its low solubility. Also ozone must transfer from the gaseous to the liquid phase. So mixer design is critical, as is ozone concentration.
- The system normally comprises a booster pump forcing pool water through an injector, which draws in the air/ozone from the generator into a mixer. Here the fine bubbles are intimately mixed with the water.
- Following mixing, the ozone residual should be in contact with the water for at least 2 minutes, preferably longer, to give as much reaction as possible between the ozone and polluting material.
- The air and undissolved ozone is released from the water and passed through an ozone removal system before it can be discharged to the atmosphere.

Safety

- Ozone is a toxic gas more stable in air than in water. Concentrations of 10mg/m3 in air lead to serious irritation and breathing difficulties. The threshold limiting value is 0.2mg/m3.
- Although ozone has a distinctive smell (like old-fashioned photocopiers) the nose is not a reliable guide for this. So it is important that the ozone

generation system fails safe and gives adequate warning on failure.

- Generators that are controlled through microprocessors are more reliable. Optimum operating safety is achieved by continuous attention to ten issues:
    - cooling water temperature
    - high-tension transformer temperature
    - air feed quality
    - loss of vacuum
    - door protection switch
    - air flow
    - current flow to regenerator, booster pump and high-voltage transformer
    - battery failure in the programmable logic controller
    - voltage/current relationship
    - interlock with water flow being treated. These should all be connected to an alarm in the event of failure. It is also necessary to ensure the ozone system is safely located:
    - an emergency shut-down switch, clearly labelled, near the door of the room
    - good ventilation
    - closed, lockable room
    - not a permanent place of work
    - restricted access sign.
    - Ozone leak detectors are strongly recommended for positive pressure ozonation systems.

Installation and maintenance

- As ozonators incorporate high-tension transformers and produce a toxic gas, it is essential that service and commissioning is done by someone qualified. They will have had specialist training, relevant experience, and be familiar with the regulations for protection and prevention of accidents. They should be in a position to judge the working conditions and confirm their safety.
- Daily records should be kept to ensure that the system is working correctly.

Dosing with ozone

- There are three different ways in which ozone can be applied to the total water volume (i.e. full treatment):
- after filtration, with separate contact and deozonising systems – the most efficient system, and best at disinfection
- after filtration but with a combined contact/dezonising system
- before filtration with combined filtration, deozonisation and contact.
- In each case the contact time between ozone and water should be at least 2 minutes; and the ozone concentration during this period should be 1mg per litre of water circulated.
- If the pool water temperature is over 32°C, the contact time should be 3 minutes and the concentration 1.2-1.5mg of O_3 /l.

Residual

- The free chlorine residual should be substantially lower than with chlorine alone – as low as will still give satisfactory microbiological monitoring results. In theory around 0.5mg/l should be possible – but much will depend on the pH, turnover rate, pool hydraulics, bathing load and the consistency with which the disinfectant residual can be maintained.
- Often 1mg/l is a more realistic target with which to maintain satisfactory microbiological quality

7 BATHER HYGIENE PROCEDURES

When not to swim

A swimming pool is not very different from any other public place. Just as people might avoid work, school or public transport when they are not well – for their own sake as much as for others – so there are circumstances when swimming pools should be avoided.

- Nobody suffering from diarrhoea should swim. That message is crucial; it should be clearly delivered and never compromised. Attention to ill children is particularly important. Gastro-intestinal bacteria and viruses are killed by pool disinfectant. With the protozoa Crytosporidium, even after diarrhoea has stopped, chlorine-resistant infective oocysts can be passed for up to 14 days. The risk of contamination will be less, but people should not swim.
- People should not go to public pools if they have open wounds, severe eczema or any infectious skin complaint.
- Colds, flu and other infectious illnesses are a sufficient reason not to swim.
- People whose illness or treatment makes them susceptible to infection, or affected badly by it, should take medical advice before swimming.
- People should not swim if they are affected by drink or drugs.
- Parents should think twice about taking infants under the age of six months to general use public pools. They may lose heat in cold water, the air may irritate their lungs, and their skin may be too sensitive for the pool chemicals.
- When children do start swimming, it should not be in nappies; there are special baby bathing costumes. But even these are of limited value in the case of Crytosporidium.
- Everyone should go to the toilet and then shower before swimming.
- Parents should make sure that children go to the toilet and then shower before swimming.
- Pre-swim hygiene should be an essential requisite by making sure heads, armpits, genitals, anal area and feet are clean before swimming.
- Children shouldn't swim on a full stomach – not because of cramp (no connection) but because they may swallow water and be sick.
- Pool managers have a duty to pass on messages like these and should have a policy on how this is to be achieved.

7.1) Pre-swim hygiene

Pool water quality would be significantly improved if everyone using the pool showered with soap before entering the pool.

- Pre-swim showers should be provided, maintained in good working condition and bathers directed to use them before using the pool.
- Toilets should be provided en-route to the pool, after changing and before showering, and everyone encouraged to use them before showering and swimming.

- Hand washbasins with liquid soap and hand-drying facilities should be provided.
- Posters, signs and staff supervision should be used to enforce all operational procedures. These should cover the issue of when not to use the pool during and after diarrhoeal illness.
- Children still using nappies should use special swimming nappies or pants, which are designed to absorb and retain soiling. Standard nappies are not adequate protection. Neither is suitable for children with diarrhoea; in this case they should not use the pool at all.
- Convenient nappy changing facilities should be provided in changing areas (these should be cleaned regularly), be equipped with basins for hand washing and have nappy disposal bins which are emptied regularly.

8 POOL WATER CONTAMINATION EMERGENCY PROCEDURES

All operators should have, as part of the EAP, written procedures, which are practised and effective for dealing with the contamination involving faeces, blood and vomit. Faeces present the biggest risk, not least because of the threat from the chlorine-resistant protozoan *Cryptosporidium* (and its cousin *Giardia*).

Faecal contamination

If a pool is contaminated with faeces, the pool operator must decide quickly on an appropriate course of action in order to prevent any possible illness in users. This is particularly important with diarrhoea, which may contain the chlorine-resistant organism Cryptosporidium ('Crypto').

So it is crucial to be prepared. It is also important to do everything possible to prevent such contamination in the first place –see the Prevention section of this Technical note.

Preparation

Operators need to be aware of the potential health risks and have the necessary procedures, equipment and chemicals in place and accessible at all times. All pools should have a written procedure, as part of their emergency action plan, stating what action to take in the event of a faecal incident. Staff must be trained in these procedures, and the training recorded.

There should also be a schematic drawing of the installed water treatment, which is vital for the informed operation of the pool and in the investigation of problems including outbreaks of infectious disease.

Dealing with a faecal incident

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

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

Solid faeces

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

1. The stools should immediately be removed from the pool using a scoop or fine mesh net and flushed down the toilet (not put in any pool drains).
2. There must be certainty that all the faeces have been captured and disposed of. If not, and there is possible widespread distribution of the faeces in the pool, then the pool should be closed and the advice below for runny faeces considered.
3. All equipment that has been used in this process should be disinfected

using a 1% solution of hypochlorite.

4. If the pool is operating properly with appropriate disinfectant residuals and pH values, no further action is necessary.
5. Depending on the extent of the contamination, how public it has been, and how quickly it can be dealt with, operators should consider clearing the pool of bathers for, say, 30 minutes while steps 1-4 are negotiated. This is certainly necessary if the faeces has broken up. Bathing should not resume until all the faeces have been removed.

Runny faeces

If the stool is watery, runny or soft (something like diarrhoea), the risk of infection is greater: the perpetrator is more likely to be carrying enteric pathogens, and if so they are likely to be spread through the pool water. It will certainly be impossible to remove the faecal material as it is with solid stool.

The infectious causes of diarrhoea include viruses, bacteria and protozoa. (Other causes include alcohol, emotion, diet and medicine side effects.) Most bacteria and viruses that cause diarrhoea – Ecoli, Shigella, norovirus, for example – are killed within minutes in a satisfactorily disinfected pool water. But if the diarrhoea contains oocysts of the chlorine-resistant protozoa Cryptosporidium, normal levels of chlorine will not be effective. Crypto is a significant cause of relatively serious gastroenteritis, particularly in pools. Young children are both the likeliest sources of the infection, and those worst affected (along with the immunocompromised).

Investigations of outbreaks linked to pools frequently reveal inadequate design and management issues, which would have made the pool vulnerable to an outbreak following contamination with diarrhoea.

In most cases of diarrhoea in a swimming pool, the operator will not know if Crypto is involved. The safest option is to assume that it is and immediately close the pool.

There are in principle three procedures that will in time remove Crypto – coagulation/ filtration, UV and superchlorination. The procedures to be followed primarily depend on the efficiency of the pool's filtration. These procedures are endorsed by Public Health England and the national Cryptosporidium Reference Unit which is part of Public Health Wales.

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

This should include most public pools. Here the main emphasis is on filtration, which if effective should remove some 99% of the Cryptosporidium ocysts in each pass of pool water through the filter. Coagulation is critical in this: it should be continuous, and the residence time (that between the injection of coagulant and treated water reaching the filter) must be long enough for flocculation to happen – at least 10 seconds at a flow velocity no more than 1.5m/ sec.

Secondary disinfection (UV or ozone) and superchlorination are also relevant – 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. As the fresh water from the filters is constantly mixing with the water in the pool it might take as long as 24 hours for all the pool water to pass through the filters – based on the 3 to 4-hour turnover period common to many pools.

This, then, is the procedure.

1. Close the pool – and any other pools whose water treatment is linked to the fouled pool. If people transfer to another pool, perhaps from a teaching pool to a main or leisure pool, they should shower first using soap and water.
2. Hold the disinfectant residual at the top of its set range for the particular pool (e.g. 2.0mg/l free chlorine if the range is 1.0 to 2.0mg/l) and the pH value at the bottom of its range (e.g. pH 7.2-7.4). This will maintain the normal level of microbiological protection.
3. Ensure that the coagulant dose is correct – for continually dosed PAC, 0.1ml/m3 of the total flow rate.
4. Filter for six turnover cycles (which may mean closing the pool for a day). This assumes good hydraulics and well maintained filters with a bed depth of 800mm and 16/30 sand. This applies also to pools with secondary disinfection.
5. Monitor disinfection residuals throughout this period
6. Vacuum and sweep the pool. Cleaning equipment, including automatic cleaners, should be disinfected after use. This will at least move faecal contamination off surfaces and into the main pool water circulation, for eventual removal.
7. Make sure the pool treatment plant is operating as it should (filters, circulation, disinfection)
8. After six turnovers, backwash the filters.
9. Allow the filter media to settle by running water to drain for a few minutes before reconnecting the filter to the pool.
10. 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 (see also below and the PWTAG technical note 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.

The procedures below also apply to tier filters.

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 (see PWTAG Technical note on superchlorination).
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. See the Technical note on superchlorination for details.
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 Crypto.

Pools with no filtration (fill and empty pools)
Here there is the possibility of emptying the pool altogether. This might apply to a paddling or plunge pool, for example. For any pool, if operators are confident that they can safely empty the pool, this is the procedure that should be followed.

1. Close the pool – and any other pools whose water treatment is linked to the fouled pool.
2. Superchlorinate the pool to 20mg/l for 13 hours or 50mg/l for 5 hours.
3. Vacuum and sweep the pool.
4. Drain, rinse and refill.
5. Re-treat and when disinfectant residual and pH are at normal levels for the pool, reopen the pool.

Pre-coat filters (including regenerative media filters)
Pools with these filters can be dealt with like those with medium-rate sand filters – but with the media discarded after the six turnovers. If, however, there is any doubt about the operation of the filters (see Technical note 25) then superchlorination (see below) may be a better option. It is important that operators use only the grade of filter medium recommended by the manufacturer.

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

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

All pools should do a risk assessment to determine whether secondary disinfection is required. The risk assessment should take into account the hydraulic and filter characteristics of the pool, as well as the risk from routine unseen contamination.

It is particularly recommended for hydrotherapy pools and pools used by young children. Their users are likely to be more vulnerable to – and to be carriers of – Cryptosporidium.

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

PWTAG's book, Swimming Pool Water, has more details about UV (and ozone) use.

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

In practice, many pools would find achieving and maintaining such residuals difficult with standard dosing equipment. Then there is the possibility of generating unwelcome disinfection byproducts as a result. And finally there is the challenge of reducing residual levels afterwards – either chemically or by water replacement.

The effectiveness of this approach is difficult to monitor, and is no quicker than the coagulation and filtration method above. Coagulation, filtration and backwashing are certainly also needed. And any UV (or ozone) plant should be switched off and by-passed during superchlorination.

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

There is a PWTAG Technical note (23 Superchlorination) with details of superchlorination and dechlorination.

Prevention
Because pool operators are unlikely to know what the cause is of any contamination with diarrhoea, and because it can get into a pool unnoticed, the best defence against infections including Cryptosporidium is good Hygiene (Swimming Pool Water chapter 3), Hydraulics (chapter 6) and Filtration (chapter 7). Secondary disinfection with UV is a good second line of defence.
Investigations of Crypto outbreaks linked to pools frequently reveal inadequate design, operation and management issues which would have made the pool vulnerable to an outbreak following contamination with diarrhoea. Attention to these issues is vital.

Prevention can be summarised:

- 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, as infective Cryptosporidium oocysts can still be released in that period. If an outbreak of cryptosporidiosis has been identified, it may be that some regular bathers will have had diarrhoea, but not had the illness diagnosed. They too should be excluded from the pool for a fortnight after symptoms have stopped.

- Encourage bathers to wash and shower before swimming. Someone who has recovered from cryptosporidiosis could still have oocysts around their anus. Pre-swim showering is good for water and air quality in any case, as it minimises combined chlorines.
- Encourage bathers to use the toilets before they swim, and wash their hands afterwards. Children should be offered frequent toilet breaks.
- Young children should ideally have their own pools. There should be good baby changing facilities, and babies should wear special swimming nappies (but not swim if they have diarrhoea). There should be provision for safe disposal of soiled nappies.
- Continuous low-level dosing of a coagulant is recommended for all pools to improve the filtration efficiency and increase the removal of any contaminants from the pool. This procedure significantly reduces the risk associated with any unseen faecal release.
- Backwashing protocol is critical; when neglected, for example, it can be a factor in outbreaks of cryptosporidiosis. Backwashing must not take place when the pool is being used and should be done at the end of bathing for the day, normally in the evening. This is because after backwashing and rinsing it can take several hours for the filter to fully ripen – a process whereby the media settles back down and re-compacts to provide an efficient filtration system. Repeated backwashing throughout the day when the pool is in use is therefore wrong.
- Backwashing of medium-rate filters should be done at least once a week or more frequently as the filter pressure differential dictates and according to the manufacturer’s literature for the filters installed.
- Avoid high-rate filters if possible. If they are in place, they may need to be backwashed more often than once a week (as the pressure difference dictates) but this should never be more than once a day, and only when bathing has finished for the day.
- Ensure there is an effective disinfectant residual, and an appropriate pH, at all times.
- The pool hydraulics should ensure appropriate turnover periods and good mixing of water in the pool; short circuits and deadlegs should be avoided.

8.1) Blood

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 nosebleed 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.

8.2) Vomit

It is not unusual for swimmers to vomit slightly. It often results from swallowing water, or over-exertion, and so is very unlikely to present a threat through infection. PWTAG recommends that vomit occurrences of this nature in the pool should be treated as if it were blood. 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. In this case the procedures outline above in 9.3 to 9.5 should be carried out

8.3) Contamination of pool surround

Any blood or vomit 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.

See Technical Note 2 – Faecal contamination February 2014 (supplemented * July 2016)

9 MONITORING WATER QUALITY

There should be documented procedures for the use of the test kits and other test equipment, and operators should be given full training in their use for monitoring pool water quality.

The documented procedures should detail actions for operators to take if there are unexpected test results, especially if they show the pool water chemical composition is either below or exceeding safe limits.

9.1) Pool water testing equipment

The manual monitoring and measurement of the chemical condition of the pool water should be performed using appropriate test kits and following manufacturers' instructions. The accuracy of test kits should be maintained by:

- Keeping them scrupulously clean (including rinsing glassware components with tap water or deionised water to ensure that all traces of test reagents from previous uses are removed)
- Cells for testing pH and chlorine should be labelled accordingly and kept separate
- Not exceeding the shelf life of the test reagents
- Following storage instructions
- Using only the test kit manufacturers' specified test tablets
- Diluting and testing a second sample for chlorine residuals (products of the reaction between chlorine and ammonia) if the first gives a result at the top of the kit's range
- Using a test kit with the appropriate range for the water under test
- Being aware of the potential effects of high calcium hardness (may give a false high reading) or pool cleaning chemicals (false low reading) on test results
- Using colour standards to ensure that the equipment remains within the calibration range and accuracy is being maintained
- Using an appropriate source of north light or an approved lighting cabinet for a comparator.

9.2) Automatic monitoring of chemical levels

This Code of Practice for public pools recommends pools have instrumentation for the continuous monitoring of disinfectant residuals (as well as pH values). This instrumentation is normally linked to the chemical dosing system, providing a more even treatment of the pool water and a closer control.

The readouts from the controller should be checked daily against the results from manual tests of the sample cell. The manufacturers' recommendations for the calibration of such equipment, including the use of suitable test solutions, should be followed. Records of all calibration tests and results should be recorded on log sheets and retained.

pH

Calibration for pH should incorporate the use of two buffer solutions, normally pH4 and pH9.2. Single-point calibration is not recommended. Readouts from the controller should be checked daily against the results from manual tests of the sample cell. If the difference is more than 0.2, the controller should be recalibrated

Disinfection

Readouts from the controller should be checked daily against the results from manual tests of the sample cell. If the difference is more than 15%, the controller should be recalibrated after first confirming the result with a further manual test.

Automatic monitors require checking daily to ensure that the readings are correct. They do not mean that manual testing of water from the pool itself is unnecessary, although the frequency may be reduced – from every two hours for manual systems to no less than three times a day with automatic systems. Automatic control does not monitor combined chlorine; to ensure adequate control of chloramines, chemical testing may need to be more frequent.

9.3) Chemical testing of pool water

Where disinfection and pH are not monitored and controlled automatically by the water treatment plant, manual testing is needed, using commercially available test kits and the appropriate tablets. The frequency of chemical testing should be determined by the risk assessment, but recommended test intervals are:

- Before the pool opens
- Every two hours while it is open
- After it closes.
- Automatic control does not monitor combined chlorine; to ensure adequate control of chloramines, chemical testing may need to be more frequent.

9.4) Sampling points

Pool water samples for chemical analysis should be taken from the pool at a depth of 100-300mm (not from the sampling cell in automatic monitoring equipment). They should routinely be taken at the deep end and furthest from the inlets – the most vulnerable part of the pool – and occasionally elsewhere.

9.5) Free chlorine levels

The values below – indeed, any values – require validation by satisfactory bacteriological water quality standards

For all pools using hypochlorite, assuming the pH value is 7.2, the free chlorine levels should be maintained at 1mg/l or below, to an absolute minimum of 0.5mg/l. This assumes satisfactory microbiological monitoring results (see section 11).

The use of secondary disinfection (UV or ozone) can help minimise the required free chlorine levels. These values can be achieved only where the pool is designed and engineered and operated well with effective pre-swim hygiene and not overloaded.

Upper limits

Free chlorine levels above 3mg/l should not be necessary in any pool using hypochlorite. If this is exceeded, dosing should be reduced.

If dosing has gone wrong and free chlorine reaches 5mg/l, chlorination should be stopped immediately; if free chlorine continues to rise bathing should cease until the fault has been rectified and the residual is under control.

9.6) Chloroisocyanurates

The same principle applies to pools on chloroisocyanurates (or with cyanurates added as a chlorine stabiliser). Chlorine residuals of up to 5mg/l may be necessary in normal operation. For pools using chlorinated isocyanurates as disinfectant, free chlorine should be maintained at 2.5-5mg/l and the cyanuric acid at no more than 150mg/l.

Some automatic controllers may not be accurate in the presence of cyanuric acid and their compatibility should be checked.

9.7) Combined chlorine levels

The level of combined chlorine residuals should be as low as possible. They should always be less than half the free chlorine, and no more than 1mg/l no matter what the level of free chlorine.

If this ratio of combined to free chlorine is unsatisfactory, some correction may need to be applied
(see *Swimming Pool Water: treatment and quality standards for pools and spas*)

9.8) pH value

The pH values for the pool water should be maintained within the range recommended for the disinfectant being used. But a pH value of between 7.2 and 7.4 should be the target when using chlorine-based disinfectants. At levels above this range the free chlorine will not be so effective and accordingly may need to be increased.

9.9) Alkalinity

To ensure effective coagulation and a stable pH when using acidic disinfectants, alkalinity in pool water should be maintained at a level between 80 and 200mg/l (measured as $CaCO_3$).
Alkalinity measurements should be taken weekly, using commercially available alkalinity test kits and the appropriate tablets. Dilution or dilute acid should be used to lower the levels of alkalinity.

9.10) Calcium hardness

Pool water should be maintained for bather comfort, and grout should withstand that water. Ideally calcium hardness should be maintained between 80 and 200mg/l as CaCO3.
However, in areas with a hard water supply this cannot be practically achieved. It is therefore very important that water treatment chemicals do not further enhance the calcium hardness content over and above that in the hard water make up supply.

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

Calcium hardness measurements should be taken weekly, using commercially available test kits with the appropriate tablets.

9.11) Total dissolved solids (TDS)

Is the sum of the weight of soluble material in water. Mains water often has a TDS of several hundred mg/l, except in soft water areas where it is considerably lower. Disinfectants and other pool chemicals will inevitably increase TDS values significantly – of chloride and sulphate in particular. Bather and other pollution will also increase levels of sodium chloride, for example. So the real value of TDS is as a warning of too many chemicals as a result of overloading or lack of dilution – and it should be monitored by comparison between pool and mains water

Dissolved solids are aggressive at high levels and should not be allowed to rise more than 1,000mg/l above the level in the source water. (There are exceptions for electrolytically generated chlorine, see PWTAG Swimming Pool Water). TDS concentration should be reduced by dilution if necessary. TDS concentration should be measured weekly, using a commercially available electronic meter that has been calibrated against a commercially available standard.

9.12) Sulphates

Sulphates are measured within the TDS figure, and when high (above 360mg/l) they can attack cementitious grout and cement. For this reason, hydrochloric acid and carbon dioxide are usually preferred to sodium bisulphate or sulphuric acid for pH correction. If, because of sodium bisulphate or sulphuric acid and aluminium sulphate (alum) use, sulphate levels cannot be kept below 360mg/l, sulphate resistant Portland cement and epoxy grout will be necessary to resist attack.

9.13) Balanced Water

It is important to maintain the water in balance, but usually this is achieved when the pH is properly controlled. Alkalinity, calcium hardness, TDS and temperature are also factors.

The Langelier index is a formula that brings together all these factors. Calculate Langelier weekly when measuring alkalinity, calcium hardness and TDS.

10 MICROBIOLOGICAL TESTING

Frequency of testing

Swimming pool water should be microbiologically tested each month to monitor for the presence of potentially harmful microorganisms.

Hydrotherapy pools, even those not in a healthcare setting, should be tested weekly.

Testing should be performed only by competent personnel at a UKAS- accredited laboratory.

Tests should also be done

- before a pool is used for the first time
- before it is put back into use, after having been shut down for repairs
- if there are difficulties with the treatment system
- if contamination has been noted
- as part of any investigation into possible adverse effects on bathers' health
- in the event of adverse results.

More frequent sampling will be necessary if there is a problem, or for particularly heavily loaded pools.

Arranging for sampling, including its frequency, is the responsibility of the pool operator.

10.1) Chemical testing at the same time

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, from the same location as a reference. The water clarity and the bather load should also be noted

10.2) Aerobic colony count (ACC)

Aerobic colony count also commonly known as Total Viable Count (TVC) at 37°C is the basic test for pool water quality and is a measure of the aerobic bacteria present in the water. It does not necessarily give an indication of microbiological safety, but gives valuable information on the general quality of the pool water and whether the filtration and disinfection systems are operating satisfactorily.

- The aerobic colony count should not be more than 10 colony forming units (cfu) per millilitre of pool water after incubation for 24 hours at 37°C
- A colony count in excess of 100cfu/ml is unsatisfactory
- A consistently raised colony count of 10 to100cfu/ml is unsatisfactory and should be investigated.

10.3) Escherichia coli (E coli)

Escherichia coli is a bacterium that is normally only found in human and animal faeces and does not grow in water. The presence of E coli indicates the presence of recent faecal contamination in the water. E coli should be absent in a 100ml sample. However, because most bathers will have some faecal contamination of their skin, particularly if they have not showered before bathing, a single positive sample may be the result of recent superficial contamination by a bather that has not yet been decontaminated by the disinfectant residual. A repeat sample should then be taken.

Coliforms

Coliforms are related to E coli but may also be found in soil and on vegetation. Their presence therefore indicates some external contamination of the pool water.

- Total coliforms should be absent in 100ml.
- Less than 10 per 100ml is acceptable provided it does not happen in consecutive samples, there are no E coli, the ACC is less than 10cfu/ml and the residual disinfectant concentration and pH values are within the recommended ranges.
- If coliform organisms are present with also a raised colony count, there is likely to be a serious defect in the pool operating system such as failure of the disinfection process and/or a problem with the chemical balance of the pool (including the pH value) or the filtration system, which will require immediate attention.

10.4) Pseudomonas aeruginosa

Pseudomonas aeruginosa is an opportunistic pathogen (An infectious microorganism that usually does not harm its host but can cause disease when the host's resistance is low.) capable of growing in water even at relatively low temperatures. It will readily colonise filters, deck level transfer channels, balance tanks and flexible polymeric materials used in some inflatables, tubing and pool covers. Most species of Pseudomonas are non-pathogenic (will not cause disease) for healthy people, but Pseudomonas aeruginosa can cause skin rashes and ear infections.

- It should be absent in a 100ml sample.
- If the count is over 10cfu/100 ml, but less than 50cfu/100 ml, the sampling and analysis should be repeated whilst maintaining the free chlorine and pH values.
- Where repeated samples contain Pseudomonas aeruginosa, the filtration, disinfection and cleaning procedures should be examined to determine whether there are areas within the pool system where the organism is able to multiply. Pool equipment e.g. swimming aids, and pool covers may also need to be checked. It can easily colonise water systems, forming biofilms and their presence requires cleaning and disinfection with a 50mg/l free chlorine solution.
- When counts exceed 50cfu/100 ml pool closure is advised as there is significant risk of bather infection.

10.5) Acting on failures

When to close the pool

- If a microbiological result is unsatisfactory, the test should be repeated as soon as practicable.
- If the second result is also unsatisfactory, the pool's management and operation should be investigated and the test repeated.
- If the third result is still unsatisfactory, immediate remedial action is required, which may mean closing the pool.
- The pool should be closed if there is chemical or physical evidence of unsatisfactory disinfection.

- The pool should be closed if microbiological testing discloses gross contamination.
- Gross contamination means one of two things:
- E coli over 10 per 100ml PLUS either colony count over 10cfu per ml or P aeruginosa over 10 per 100ml (or, of course, both)
- P aeruginosa over 50 per 100ml and colony count over 100 per ml.
- Closure procedures for microbiological failure should be included in the pools EAP

11 PLANT ROOM

The plant room should be a secure area for authorised personnel only. Plant rooms should be adequately sized and not used for general storage, or for storing hazardous chemicals, unless appropriate precautions are taken. There should be no risk from fire or overheating.

- The location of the filtration and water treatment system in relation to the pool critically affects hydraulic design. Circulation pumps should, ideally, operate under flooded suction conditions and be sited near the balance tank, and near the extraction points from the pool.
- If the plant room has to be at pool surround level, a pump pit will give flooded suction conditions.
- If there is no balance tank, the connection between pool water and pumps should be designed to keep the system free of air entrainment.
- It should be sized and located to ensure good access, both to the plant room itself and for plant room equipment operation, delivery of chemicals (including size of vehicle), maintenance and replacement.
- Filters should be accessible and there should be good access to balance tanks.
- Certain equipment needs segregation. For example,
  - chemicals should be stored in separate, secure rooms and with sufficient space for liquids to be stored in separate bunded areas capable of taking 110% of the volume stored. Chemicals should only be stored where there is no risk of fire or overheating in containment structures or devices designed to control spillages. There should be adequate separation from other chemicals and substances stored in the plant room; containers should be kept securely closed, cool and dry. Chemicals supplied in paper or plastic sacks should be stored in plastic bins before opening, and securely closed after use.
  - Electrical control panels, chemical control units, ozone generators etc should be in clean, dry, well-ventilated areas away from chemical stores, and on raised concrete work plinths.
- Certain plant items demand a specific environment. For example, there are important requirements (under COSHH) for ventilating ozone plant, electrolytic chlorine and chlorine dioxide generating equipment and chemical mixing areas.
- Most electrical items will require limits on plant room air temperature and humidity.
- There is also a requirement for effective and suitable plant room ventilation in the Workplace (Health, Safety and Welfare) Regulations 1992.

11.1) Safety systems provided and maintained

Relevant safety systems (e.g. chlorine gas detectors, fire/smoke detectors), safety equipment and personal protective equipment should be in the plant room, and should also be maintained in accordance with a planned programme. Monthly inspection of personal protective equipment is required to check its continuing suitability.

11.2) The pool operator

The pool operator must provide suitable information, instruction and training for employees operating pool water treatment plant and equipment and ensure that a risk assessment of the plant room is carried out.
The plant room should contain:

- an eyewash station;
- a nose and mouth respirator (EN 140:1998 and EN 141:2000);
- rubber gloves (BS 1651);
- goggles or face shield (BS 2092);
- wellington boots (BS 1870);
- apron or overalls (BS 1870);
- a full-face respirator, to Chemical Works Regulation 1922.

11.3) Confined Spaces

Cleaning or maintenance activities may require employees or contractors to enter confined spaces. A confined space is a place which is substantially enclosed (though not always entirely, for example a pool balance tank after it is emptied) and where serious injury can come from hazardous substances or conditions within the space or nearby (e.g. lack of oxygen).

If work is required on plant or equipment in confined spaces pool operators should have arrangements in place to ensure the work can be done safely. The following principles apply:

- Working in a confined space avoided whenever possible, for example by doing the work outside
- Where confined space working is required, staff must have appropriate training in accordance with the regulations (see below)
- A safe system of work if working inside
- Appropriate arrangements for rescue in an emergency.

Detailed guidance on managing the risks from work in confined spaces is available at http://www.hse.gov.uk/confinedspace/

12 CHEMICALS

12.1) Control of Substances Hazardous to Health Regulations (COSHH)

COSHH requires employers to control substances that are hazardous to health. These can take many forms and include chemicals, mists, vapours, fumes, gases and asphyxiating gases and germs that cause diseases (www.hse.gov.uk/biosafety/infection.htm).

Typical hazardous substances include:

- sodium hypochlorite;
- calcium hypochlorite;
- chlorinated isocyanurates;
- acids;
- bromochlorodimethylhydantoin;
- bromine;
- microbiological organisms in pool water, for example, legionella and cryptosporidium (due to contamination from a failure to manage pool water quality and hot and cold water systems or a breakdown of existing control measures. Faecal fouling will also introduce risk of infection from harmful organisms).
- Risk must be assessed for each chemical and microorganism.
- Assessment should be done by a competent person. The assessor will need to know about which chemicals are used and how; other chemicals on site; site location in relation to the impact of a chemical accident; staff training and competence in using chemicals; risks to health arising from microorganisms.
- Exposure to hazardous substances must be prevented or controlled.
- 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.

Risk minimisation

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 using the least potentially harmful (but effective) chemical or 'engineering' control measures 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.

COSHH Regulations require suppliers of chemicals to provide a safety data sheet (SDS) for each chemical. SDSs must be provided free by suppliers before the

product is delivered. Updates are also free, as are SDSs for anyone using chemicals at work
These should be displayed in the vicinity of the chemicals. It is also the plant installer's responsibility to provide relevant information on plant safety etc. - which may include SDSs.
There will need to be SDSs for all the chemicals in the plant room including pool chemicals, cleaning chemicals, pool water testing chemicals and chemicals used in maintenance programmes.

12.2) Training in chemical handling

Pool operators must provide information, training and instruction for employees who work with substances hazardous to health (www.hse.gov.uk/coshh/basics/training.htm). This includes cleaning staff, lifeguard staff and maintenance staff.
Pool operators should also ensure that contractors understand their responsibilities and follow procedures. Pool operators should monitor compliance with procedures and review them periodically and after any incidents. There is more information on managing contractors at
www.hse.gov.uk/managing/delivering/do/organising/managing-contractors.htm.

Training should include the knowledge and understanding of the chemicals needed for staff to be alert to any changes affecting safety.

The training for the safe operation and use of equipment and chemicals should be:

- Related specifically to the particular situation and hazards associated with it, and substances used
- Given to enough employees to ensure that plant need never be operated or process conducted by untrained staff
- Include pool managers, to ensure they understand chemicals hazards and the functioning of the pool water system
- Include the use, care and maintenance of personal protective equipment.

12.3) Danger of contamination

All chemicals generating chlorine on contact with water (calcium and chlorinated isocyanurate and bromochlorodimethylhydantoin) need to be kept cool (temperatures should not exceed 30˚C), in closed containers and away from dampness and contamination by organic materials such as grease. Ammonia is particularly dangerous in contact with chlorinating agents. Some chemicals react with strong acids and some with alkalis or even each other.

- Do not attempt to mix chemicals, even apparently similar types.
- Only use chemicals in the specific circulation feeder designed for them

12.4) Personal protective equipment (PPE)

Where it is reasonably practicable to do so, engineering controls, such as automatic dosing systems, must be used in preference to PPE. PPE must only be used as a last resort, but even where engineering controls and safe systems of work have been applied, some hazards might remain. If so, pool operators must identify the PPE required for specific tasks and the level of protection it provides.
Pool operators should take the advice of suppliers about what PPE is needed. Some or all of the following protective clothing should be provided on site for use

by authorised, trained staff, during delivery, handling of materials, cleaning or maintenance: dust masks and face protection, eye protection aprons or chemical suits; boots; gauntlets; respirators.

- Impervious chemical resistant wellington boots to BS 1870 should be worn to prevent feet and ankles becoming contaminated with accidentally splashed chemicals. Trousers should be worn outside the boots (i.e. not tucked in), to stop spilt chemicals entering through the top of the boots.
- Chemically resistant aprons or overalls to BS 1870 should be worn to protect the front of the body whenever chemicals are dispensed.
- Chemical resistant rubber or PVC, gauntlet style gloves to BS 1651 should be used for all handling procedures. Sleeves should extend over the gloves to prevent the entry of chemicals. After use, the outside of the
- Gloves should be washed before removal and then both the inside of the gloves and hands washed with soap and water.
- Safety goggles or face shield to BS 2092 should be worn to protect the face when handling any chemical.
- Dust respirators are appropriate when handling granules and powders.

Respirators
Full-face respirators fitted with a combined acid gas and particulate filter should be on site. This will provide suitable eye and respiratory protection and should be used whenever minor leakages of chlorine gas may be encountered.
However, these respirators cannot be relied upon in a major chlorine leak. Canister respirators can only deal with low concentrations of toxic gases. Pool operators must have suitable emergency procedures for more serious leaks, where appropriate in consultation with the fire authorities.

- A respirator and fitted combined B2P3 filter should be sited immediately outside the chlorine plant room, with a further respirator near to hand at any point where a leak of chlorine gas may be anticipated. In both cases adequate, clean storage accommodation should be provided for the respirators.
- When a respirator is used it is essential that a good seal is achieved between the respirator and the user’s face and suitable training in this technique should be provided for all authorised staff.
- The combined filters have a limited life and therefore each use should be recorded in the daily logbook. The manufacturer’s instructions
- Canisters need to be replaced in accordance with the expiry date marked on them. The period of exposure should be recorded and when the number of hours exposure is exceeded the canister should be replaced

12.5) Chemical spillage

In any emergency a quick but calm reaction is necessary.

- Personnel and the public should 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 chemical 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) the area should be immediately evacuated; sources of ignition removed; maximum ventilation provided.

- If the risk to people or environment is considerable, emergency services should be called.
- Only personnel with proper respiratory and eye/skin protection should be permitted in the area.
- Spillages should be dammed and absorbed with dry sand, soil or other inert material – not combustible absorbents such as sawdust.
- The absorbed material should then be collected in containers, sealed securely (with a vent) and delivered for disposal according to local regulations. Containers with collected absorbed material should be properly labelled with correct contents and hazard symbol.
- The spillage site should be washed well with water and detergent; being alert to the potential for surfaces to become slippery.
- The site of the spillage should continue to be ventilated.
- Spillages or uncontrolled discharges into watercourse, drains or sewers should be notified immediately to the Environment Agency 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, it should be absorbed and disposed of as above.

Leaks in the piping or discharge hose
The primary valve at the base of the storage tank should be closed. In leaks in piping or hoses, closing a valve between the leak and the source of the material will minimise the loss.

Leak in the bulk storage tank, or its primary valve
The tank should be emptied as quickly as possible into other suitable containers – which might be an IBC. The supplier of the tank should be notified. Lowering the level of the product in the tank stops or reduces the leak. The material should then be drummed and returned to the supplier for recycling. Uncontaminated spillages may be able to be used in the pool.

Cleaning up other material in the containment bund
Sodium hypochlorite is best diluted by about 10 times and then neutralised with sodium thiosulphate pentahydrate. Heat is generated in all neutralisation reactions.

Dry chemicals
Should be gently swept up using a clean, dedicated dust pan and brush (after the operator has put on the respirator and other protective clothing) and placed in a clean, dry, plastic container for subsequent disposal. The affected area should then be washed down with copious amounts of water.

12.6) Toxic Gas Leaks

There should be an emergency action plan (EAP) for dealing with any major release of toxic gas. The procedure should include arrangements for:

- Evacuation of areas if there is a fire or toxic gas emission should be addressed in an emergency evacuation procedure. This should specify designated safe areas, assembly points and toxic gas shelters. The procedure should also identify responsible staff whose duties during area evacuation include:
    - responsibility for a specific area
    - ensuring roll calls are undertaken to identify missing persons
    - communication of missing persons to central emergency services
- In certain exceptional circumstances premises may be subject to COMAH where threshold quantities of dangerous substances identified in the regulations are kept or used. Further information is available at www.hse.gov.uk/comah/index.htm.
- co-ordination with emergency services, including informing them immediately of hazardous substances present (unless they already have this information).

12.7) Chemical safety information on site

Pool operators should provide your employees with adequate information, instruction and training. Follow the advice provided on the package labels and, where appropriate, in Safety Data Sheets;

12.8) First Aid

First aid provision should include equipment for dealing with the consequences of direct contact with chemicals; for example, by providing eyewash bottles and emergency drench showers.

- Eyewash facilities should be located in close proximity to the hazard to enable immediate action.
- A washbasin with running water should be provided in case chemicals come into contact with the skin or eyes.
- Where staff could be subject to severe exposure to a harmful chemical, emergency drench showers should be provided. The delivery of water should be at high volume but low pressure to reduce the risk of injury or further contamination. The volume should be sufficient to immediately drench the person (for showers, typically 75 l/min, for eye-wash 1.5 l/min) and there should be sufficient flow to last around 15 minutes. Consequently, simply using hoses connected to mains water is not suitable.
- Employees must been trained in the proper use of such equipment and it should be maintained in accordance with the manufacturer’s instructions and tested weekly.

12.9) Delivery of chemical

When materials are delivered, make sure there is enough space for maneuvering and parking close to the storage area. Take precautions (for example supervision, warning signs, or barriers) to protect the public or workers who may have access to the delivery area. Move materials into storage as soon as possible, and do not leave them unattended in a public area.

Offloading

Pool operators must have safe systems of work in place to ensure that bulk deliveries of chemicals are properly managed. This will include:

- a delivery procedure agreed with the supplier and haulage company;
- procedures to ensure that incompatible materials are effectively
- segregated;
- designated pipework with connections that are easily identifiable and unique in size and/or shape so as to prevent inadvertent misconnection;
- making sure employees wear any required Personal Protective Equipment (PPE);
- making sure emergency procedures are in place if there is a spillage.
- It is essential that all deliveries proceed only when a trained staff member is available to receive and check the materials.
- All staff involved in chemical offloading should have specific training in delivery of chemicals, dealing with spillages and manual handling.
- Unloading should not be on the public highway. Where this is unavoidable, local authority permission should be sought and suitable warnings provided.
- In general, cylinders and other containers of over 25kg will be delivered either on vehicles with a tail lift, or on platform vehicles with a slide or skid that allows containers to be lowered to the ground. A delivery dock at the same height as the delivery vehicle is an acceptable alternative, as is a forklift truck.
- The driver may need help offloading (and no delivery should go ahead if there is no-one to receive it).
- The responsibility for offloading and onloading is joint between customer and driver.
- The driver's responsibility ends when the container reaches ground or dock level.
- No container should ever be dropped to the ground.
- The safe working load (SWL) of any lifting apparatus used should not be exceeded; regular inspection, testing and certification should be observed.

Bulk delivery of sodium hypochlorite and hydrochloric acid

For bulk deliveries, a written delivery procedure should be agreed with the supplier, in accordance with hazard data sheets.

- Pipework should be clearly labelled and specific to the delivery of that product, to prevent delivery hoses being incorrectly connected up. It is important that any other chemical delivered in bulk has a separate, different size or type of connection. Pipework fill points should be clearly labelled and locked when not in use.
- Bulk tanks can be connected to day tanks either by gravity or pumping, but there should be separate fill routes and/or pumps for each chemical.

- Incompatible materials (for example acid and alkali), if delivered in the same vehicle, should be effectively segregated.
- The whole process should be the specific responsibility of a nominated member of staff. That supervisor should have had suitable training on the product and its operation, and:
- have a clear knowledge of the offloading procedures and handling precautions
- supervise the offloading operation throughout
- make sure the correct product is being delivered and that the quantity supplied corresponds to that ordered and the identification marking on the tank
- make sure that there is room in the tank for the full quantity being delivered
- pay particular attention to the level in the bulk tank, before and during offloading
- check that the drain valves on the storage tank filling line are closed
- instruct the driver to connect the flexible hose to the correct intake pipe; check that the connection has been made correctly, and that there is no restriction to flow
- sign the discharge consent notice before instructing the driver to start pumping; and stop the driver from pumping if the procedure goes wrong in any way, or when the correct amount has been offloaded
- when the right amount has been offloaded, close the valve on the filling line; when drainage stops, instruct the driver to disconnect the flexible hose
- deal with any spillages and drainage
- Bulk and day tanks should be in separate bunds sized to take 110% of the volume of the tanks.

Transport from offloading area to store

- Chemical containers should not be left unattended at the offloading site, especially where it is open to the public. In any case, materials should be stored away in a cool place as soon as possible – especially sodium
- hypochlorite, whose decomposition is accelerated by sunlight (causing pressure rise within the container). Sodium hypochlorite should always be stored in supplied containers with a built-in vent or vent cap.
- Containers should be kept upright, and never rolled.
- Containers over 18kg should be risk assessed for handling. Nothing over 25kg should be lifted by one person; or even two, ideally. Instead, custom-built wheeled carriers should be used, with warning labels.

12.10) Chemical storage essentials

Each chemical should be stored separately from all other chemicals

- All containers, and filling, feed and delivery lines, should be clearly labelled – including corrosive warnings as appropriate.
- Disinfectant and ancillary chemicals should not be stored in the same room/area as any other chemicals or materials – in particular, kept away from petrol, oils, solvents, fertilisers, other strong acids or alkalis,
- ammonia and its compounds, and cleaning materials.

- Dilution should be by adding the chemical to water, not the other way round.
- The accidental addition of acid to hypochlorite is the commonest cause of chlorine release incidents in pool buildings. PAC added to hypochlorite has a similar effect.
- All containers should be kept securely closed, cool and dry (and out of direct sunlight).
- Chemicals supplied in paper or plastic sacks should be placed in plastic bins before opening, and securely closed after use.
- Containers should ideally be returnable; if not, they should be flushed out with plenty of water before disposal to general rubbish as empty uncleaned packaging which does not require a waste disposal licence.
- Products no longer required should be safely disposed of.
- Chemicals should be stored in containment structures or devices designed to control spillages, they can be permanent (e.g. bunds), portable (e.g. drip trays) or built into equipment (e.g. double skinned tanks).
- Safety data sheet (SDSs)s should be available at the point of storage.

12.11) Chemical store

Chemical stores should provide clean and dry storage for solid materials to avoid contact with water and should also be protected from sunlight and hot pipework or plant. Chemical stores should:

- Have warning signs, be secure and accessible only to authorised, appropriately trained people
- Be at the same level as the delivery point and not be situated close to public areas, doors, windows or ventilation intakes
- Have adequate natural ventilation to a safe open area or mechanical ventilation providing four air changes per hour.

12.12) Dosing practice

- To ensure good quality water, automatic dosing is best for all pools, and essential for public pools
- Manually operated and monitored dosing systems should also be backed up by good management of operation, monitoring and record-keeping.
- Trying to compensate for inadequacies in treatment by shock dosing is bad practice
- Dosing pumps should be designed fail safe and shut themselves off if the circulation system fails
- pH adjusting chemicals are best dosed downstream from the filters – where possible, after the heat exchanger.
- It is important that disinfectants and pH value adjusting chemicals are well mixed with the water at the point of dosing.
- Hand dosing (i.e. putting chemicals directly into the pool) is rarely justified in pools. (Dichloroisocyanurate – and rapid-dissolving calcium hypochlorite can be exceptions.)
- Dosing systems, like circulation, should continue 24 hours a day to maintain stable conditions for bathers.
- Alkaline chemicals can block injection fittings, when used with hard water; regular cleaning will be necessary.
- Where appropriate, day tanks should be used to reduce the chance of major accident through over-dosing. Day tanks reduce the amount of chemical that

can be incorrectly dosed into the system should there be a failure. They should be bunded so spillages are contained.

- As different chemicals are usually incompatible, the dosing systems as well as the tanks should be kept separate and bunded separately. There should be separate pumps for transferring each chemical from its supply container to the day tank.
- All systems should be fail safe: no fault should create dangerous conditions.
- All chemical pipework, suction and delivery lines and tanks should be labelled to meet regulations and to identify the exact contents.
- Pipes should be labelled with the direction of flow as well as coded for their contents.
- Suction lines, dosing pumps, delivery lines and injection points should be as close as possible to the flow and return pipework, to avoid extended systems.
- Dosing can best be achieved by using a chemical loop system (see Swimming Pool Water).
- Sodium hypochlorite is best dosed when the dosing pump is under flooded suction with some means of removing any oxygen gas that has collected through degradation of the hypochlorite before pumping.
- Pipe runs should be as short as possible.
- All materials should be corrosion-resistant – externally as well as internally – and able to withstand the pressure in the system.
- Pipe runs containing strongly aggressive chemicals should be double contained (sleeved) where leakage could damage people or plant.

Where to dose

Dosing disinfectant before the filter prevents inadvertent mixing of disinfectants and acids (which are added post-filter). But there are arguments for disinfectant dosing post-filter; (this issue is dealt with in *Swimming pool water*). With UV and ozone (which remove or reduce residual chlorine), dosing is always after the secondary treatment.

Circulation feeders

Circulation feeders, which hold tablets of disinfectant, should be used only in accordance with the manufacturers' instructions. Although feeders are used for a variety of chemicals, it is vitally important that each feeder should be used only for what it is designed to feed – and never for a second chemical. Using the wrong chemical – calcium hypochlorite in a trichlorinator, for example – can destroy the feeder by a combination of chemical and heat attack. And if calcium hypochlorite and chlorinated isocyanurate get mixed as a result of putting both in the same feeder, nitrogen trichloride gas will be produced – with potentially explosive results, which can be fatal for the operator.

- Ensure the feeder is compatible with the chemical being dosed.
- Feeders should not be used for any chemical or size of tablet other than that specified.
- Trichlor tablets in use should be kept completely submerged and should be fully used up prior to extended periods of circulation shut down.
- If the pool circulation is shut down for some time, the tablets should be removed from the feeders. Rather than leaving them wet and exposed, when they will tend to produce chlorine fumes, they should be put in

water.
- Feeders should not be sited near a heat source: trichloroisocyanuric acid, for example, will explode on over-heating.

12.13) Chemical dosing operations

Chlorine gas can be generated and an emergency arises where disinfection chemicals mix inadvertently with pH correcting chemicals. This can happen when pool chemicals continue to be dosed when main pump circulation fails.

- Chemical dosing systems monitors and automatic controls should be interlinked with the circulation pumps and the circulation of water through the system, so that dosing stops if there is pump failure or significant loss of pumping rate. These systems should always fail to safety and require manual restart when circulation is restored.
- Further protection is provided against the effects of continued dosing when water circulation fails if chlorine disinfection is dosed pre filter and pH-correcting chemicals dosed post filter.
- 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 in filling lines between the day and bulk tanks should not be closed, as decomposition products might otherwise build up. After such a shutdown, the whole of the dosing system should be flushed through gently with low-pressure water.
- Blockage of sodium or calcium hypochlorite injection points can be minimised by adding sodium hexametaphosphate to the dosing tank.

Injection fittings for alkalis – including hypochlorites – should be withdrawable for descaling.
Dosing systems that avoid injection points are best.

- All injection fittings should incorporate a non-return valve to prevent pool water from entering the chemical dosing system – particularly when the plant is shut down.

12.14) 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.
- If hydrochloric acid is not being dosed direct from a container and is then automatically diluted, it should be diluted to a weaker solution by filling the day tank with a known quantity of water, adding a known quantity of acid to it, and mixing thoroughly. For small pools a 5%v/v solution is ideal and reduces atmospheric corrosion.
- Any sludge formed from the incomplete dissolving of chemicals should be cleared periodically but if the solutions are prepared correctly this should not happen.

13 POOL CLEANING - EQUIPMENT AND SURFACES

All floors in the pool hall area, changing rooms, toilet and shower areas should be thoroughly cleaned each day.

13.1) Cleaning the pool surround

Pool surrounds should be cleaned at the start of each day by washing and scrubbing with 100mg/l chlorinated water (1ml of 10% w/w sodium hypo in 1 litre of tap water).

- 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.
- 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.

13.2) Cleaning the water line

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.

13.3) Transfer channel

Some pools have a transfer channel fitted with a drain valve, 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 can be cleaned and it can also be used to take any cleaning residue from cleaning the pool surround. By opening the drain valve and thoroughly flushing, the cleaning residue goes to waste.

13.4) Cleaning agents

Proprietary chemical cleaners should be avoided altogether if possible. 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).

If this is not possible 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.

13.5) Proprietary cleaners where used

If proprietary cleaners are required, they should be formulated for poolside use, and come from reputable suppliers (even though the target is to prevent them getting into the pool water).

13.6) Chemical cleaning agents and pool water

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

13.7) 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. Care should be taken when using acid descalers in the presence of cementitious grout as prolonged contact at too high a strength may dissolve the grout. It is important that no residue from these cleaning programmes returns to the pool water.

13.8) Showers

Showers should be supplied with fresh water. Shower water should be stored at 60°C, and distributed so that it reaches at least 50°C at the feed to the shower and mixed at or within 2m of the point of use to 40°C (± 2°C).

- Showers should run to waste.
- All showers installations should comply with HSG 274 part 2. The control of legionella bacteria in hot and cold water systems.
- All showers should be cleaned and descaled in accordance with HSG 274 part 2 requirements

13.9) Pool covers

Pool covers should be checked regularly for any contamination, cleaned as necessary and disinfected with 100mg/l chlorinated water (1ml of 10% w/w sodium hypo/ 1 litre of tap water)).

13.10) Pool equipment

Any equipment, especially floating types, should be checked to ensure they are hygienic and clean before being used in the pool. This includes inflatable play devices, canoes, sub aqua equipment, arm bands, floats etc. They should be regularly cleaned physically, disinfected with 100mg/l chlorinated water solution (1ml of 10% w/w sodium hypo/ 1 litre of tap water) for 20 minutes, and dried prior to storage.

13.11) Transfer channels

Deck-level transfer channels should be cleaned as required, at least once a month. They should be drained and flushed out with 100mg/l chlorinated water (1ml of 10% w/w sodium hypo/ 1 litre of tap water)) which can be returned to the balance tank. Grilles should be scrubbed weekly with 100mg/l chlorinated water.

13.12) 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 100mg/l chlorinated water (see 8.1), which can be returned to the circulation system via the filters.

13.13) Pool bottom

The pool bottom should be kept clear of contamination, algae, and general debris by daily sweeping, suction cleaning or other means.

13.14) Pool shell

If a pool is emptied, then the bottom and sides should be scrubbed thoroughly with 100mg/l chlorinated water (1ml of 10% w/w sodium hypo/ 1 litre of tap water)) before refilling. It should be flushed thoroughly to drain before refilling. Check the integrity of the structure while the pool is empty.

14 HEATING AND AIR CIRCULATION

Maintaining satisfactory environmental conditions is essential for the comfort of bathers, lifeguards, staff, spectators etc., and for the pool to operate successfully over its working life.

14.1) Pool water heating

Table 3 gives recommended temperature ranges for different types and use of pool

Table 3 Pool Temperatures:

Pool use	Temperature range (°C)
Competitive swimming and diving, fitness swimming, training	26-28
Recreational swimming and adult teaching	27-29
Leisure waters	28-30
Children's teaching	29-31
Babies, young children, disabled and infirm	30-32
Hydrotherapy and aquatic rehabilitation pools	32 -36 Ideally at 34.5ºC (thermoneutral).

14.2) Pool hall air

The pool hall air temperatures should be no more than 1deg C above or below that of the water temperature.

- Air temperatures over 30°C should be avoided.
- Hydrotherapy and aquatic rehabilitation pool air temperature should be maintained at approximately 25-28°C
- Relative humidity should be maintained at a level of 60% (no less than 50%, no more than 70%) throughout the pool hall area.
- The pool hall area (water plus wet surrounds) should preferably be ventilated at a rate of over10 litres of ventilation air per second per square metre of pool hall area.
- Where leisure pools include extensive water features, consideration should be given to an increase in the ventilation rate.
- Ventilation systems should be designed to provide a minimum of 12 litres per second of fresh air for each occupant of the pool hall (bathers, staff and spectators). An extra 10% on top of the running rate should be available when necessary (e.g. for temporary higher bather loads or if high levels of contaminants are detected in the pool atmosphere)
- Where the ventilation system is capable of using recirculated air, at least 30% of the air content should be provided from a fresh source where possible.

15 TERMS AND DEFINITIONS

For the purposes of this CoP, the following terms and definitions apply.

1. Acid - A chemical with a pH of less than 7.0, used to lower the pH value when added to pool water.
2. Air scour - Air forced up through a filter bed prior to backwash to expand the filter media and loosen dirt particles.
3. Algae -Simple form of microscopic plant life that thrives in sunlight and can make pool water cloudy or green.
4. Algicide - A chemical that aids in killing, controlling and preventing algae.
5. Alkali -A chemical with a pH above 7.0 used to raise the pH value of pool water; also called a base.
6. Alkalinity -A measure of the alkaline content of water; generally expressed in mg/l or ppm; a measure of the resistance to change in pH value.
7. Aluminium sulphate - (alum) A coagulant, usually crystalline.
8. Ammonia - A chemical formed from the breakdown of urea in urine and sweat.
9. Amperometric sensor - Pool water sensor that measures, for example, hypochlorous acid.
10. Backwashing - Cleaning of the filter by reversing the direction of water flow up through the filter media to waste.
11. Backwash holding (attenuation) tank - A reservoir needed where the drainage system cannot accept the full backwash flow.
12. Balance tank - A reservoir of water between the pool and the rest of the circulation system. It maintains a constant pool water level and supply to the pumps, and holds water displaced by bathers.
13. Bather load - A measure of the number of bathers in a pool over a set period of time.
14. BCDMH Bromo-chloro-dimethyl-hydantoin - A solid type of bromine disinfectant.
15. Breakpoint chlorination - A disinfection method in which chlorine dose is sufficient to oxidise rapidly all the ammonia nitrogen in the water, and to leave a suitable free chlorine residual to protect against cross-infection in the pool. When the combined chlorine level in the pool falls, after rising as chlorine is added, this indicates that nitrogenous pollution is being successfully oxidised.
16. Bromamines - A disinfection byproduct from the action of bromine on ammonia and other nitrogenous wastes.
17. Bulk tank - A tank designed to hold chemicals in bulk. The tank should be marked with the chemical name and have a level indication so that it is clear when it needs to be filled, and when it is full.
18. Bund - A spillage containment tank for chemicals.
19. Buffer - A chemical (or mixture of chemicals) which helps pool water resist changes in pH value.
20. Calcium chloride - A Chemical used to increase calcium hardness.
21. Calcium hardness - A measure of the calcium salts dissolved in pool

water.
22. Calorifier - A heat exchanger used to heat pool water indirectly.
23. Carbon dioxide - A gas which dissolves in water to form the weak carbonic acid, used to lower pH.
24. Chloramine - Disinfection byproduct from the action of chlorine on ammonia and other nitrogenous wastes.
25. Chloroform - A product of the reaction between chlorine and organic nitrogen compounds; one of the trihalomethanes.
26. Coagulant - A chemical which produces a gelatinous precipitate in water and causes the agglomeration of finely divided particles into larger particles which can be filtered out.
27. Coagulation - The action of a coagulant.
28. Coliforms - Bacteria occurring in human and animal faeces but also capable of survival and growth in soil and on vegetation. The group includes E. coli
29. Collectors - (laterals, filter nozzles, underdrains) Interior bottom p art of the filter that collects the filtered return water.
30. Colloids - Very fine suspended matter in water, which does not settle and contributes to turbidity.
31. Conductivity - Electrical measurement of ions in water used to estimate total dissolved solids in swimming pool water.
32. Combined chlorine - A measure of the chloramines in pool water.
33. Cyanuric acid - A stabiliser that can be added to pool water to reduce chlorine loss due to sunlight.
34. Day tank - Tanks designed to hold the amount of dosing chemical to fulfil a day's needs. Each different chemical should be separately bunded (walled around so spillages are contained).
35. Deck-level - A pool with the water and poolside deck at the same level, and having a transfer channel to remove surface water to the balance tank.
36. Disinfection – Process of inactivating potentially harmful micro organisms in pool water.
37. De-ozonation - Removing ozone from water before it returns to the pool.
38. Dichlor - Short for sodium dichloro-isocyanurate dihydrate (and also called Troclosene sodium dihydrate). A type of stabilised pool chlorine disinfectant.
39. E coli (Escherichia coli) - A bacterium found in human or animal faeces that is normally incapable of growth outside the intestine– its presence in water indicates faecal pollution.
40. Erosion feeder - A simple device that allows a steady flow of water to erode a stick or tablet of disinfectant, liberating the active ingredient.
41. Filtration - Removal of colloidal and particulate matter by passing the pool water through filter media, usually a sand bed.
42. Filtration rate - The velocity of water through a filter, measured as metres per hour (m/h), equivalent to m3/m2/h.
43. Flocculants see coagulant - A chemical compound (e.g. aluminium chloride, poly aluminium chloride) that improves filtration by causing the particles produced by coagulation to come together to form large accumulations, or flocs.

44. Flooded suction - Describes the arrangement where the pump and suction pipework are below pool water level.
45. Flow meters - Measure normal flow and the backwash flow rate.
46. Fluidisation - Suspension of the filter media when backwashing and sometimes air scouring.
47. Folliculitis - An infection of the hair follicle caused by bacteria, usually Pseudomonas aeruginosa.
48. Free chlorine - A measure of the chlorine residual (the sum of hypochlorous acid and hypochlorite ion) that is available for disinfection.
49. Gas chlorinator - A device that controls the release of chlorine gas from bulk supply.
50. Halogen - The chemical family that includes chlorine and bromine (and iodine).
51. Hardness - A measure of all the calcium and magnesium salts in pool water (total hardness). See also calcium and permanent hardness.
52. Headloss - The difference in water level between the upstream and downstream sides of a treatment process attributed to friction losses; sometimes called pressure drop.
53. Heat pump - Heat pump coils remove heat or cool energy from one location and direct it to another.
54. Humic acid - A constituent of mains water that reacts with halogen disinfectants to form trihalomethanes.
55. Hydrochloric acid - An acid used to lower pool water pH value.
56. Hypobromous acid - The main active factor in all bromine disinfectants.
57. Hypochlorite-based disinfectants (hypo) Sodium hypochlorite (liquid pool chlorine); calcium hypochlorite (solid pool chlorine).
58. Hypochlorous acid - The main active factor in all chlorine disinfectants.
59. Injector - Fitting enabling a chemical liquid or gas to be injected into the water circulation loop.
60. Ions - Electrically charged chemical particles.
61. Langelier index - A measure of the scale-forming or corrosive nature of water.
62. Loss of head - Describes the loss of operating pressure (at the filter or pump outlet).
63. Make-up water - Fresh water used to fill or top up pools, particularly after backwashing.
64. Nitrogen trichloride - The most irritant of the chloramines.
65. Nephelometric turbidity unit (NTU) - Unit of measure used in the measurement of turbidity.
66. Oxidation - The process by which disinfectants remove pollution.
67. Oxidation-reduction potential (ORP)- A measure of the oxidative powers of the water, which is measured in millivolts.
68. Ozone - Gas generated on-site and used to purify pool water by oxidation.
69. PAC (Poly aluminium chloride) - A commonly used liquid coagulant.
70. Permanent hardness - That part which does not precipitate from the water on heating; it consists of calcium and magnesium salts other

than carbonates and bicarbonates.

71. pH - A measure of the acidity/alkalinity of water on a logarithmic scale of 0–14.0. A pH below 7.0 is acidic and above 7.0 is alkaline basic.
72. PPE - Personal protective equipment may include safety goggles, hearing protection, gloves and coveralls.
73. ppm - Parts per million a measurement that indicates the amount of chemical by weight in milligrams per litre of water (mg/l) these are numerically the same.
74. Pressure gauges - Measure the headloss across the filter bed.
75. ORP sensors - Pool water analysers that measure only the oxidative power of the water. See Oxidation-reduction potential.
76. Salt chlorinator - An electronic device that produces free chlorine from sodium chloride.
77. Scaling - The deposition (usually calcium carbonate) on pool walls, pipework, etc.
78. Sensor - An electrical or electronic device for measuring a specific parameter, for example pH, water flow, chlorine, ORP, temperature.
79. Shock dosing (superchlorination) - Reactive dosing of higher levels of chlorine to combat chloramines, growth of algae and other forms of contamination. It needs to be followed by dechlorination – if only by allowing sufficient time for residuals to fall to acceptable levels.
80. Sodium bicarbonate (bicarb) Used to raise total alkalinity.
81. Sodium bisulphate (dry acid) Used to lower pH.
82. Sodium carbonate (soda ash) Used to raise pH.
83. Sodium chloride (common salt) Added to pools with salt chlorinators.
84. Sodium thiosulphate pentahydrate Used for dechlorination of pool water (e.g. where free chlorine levels are excessive) and microbiological samples.
85. Total alkalinity - Measure of alkalinity used to determine pH buffering capacity of pool water.
86. Total chlorine - A measure of free plus combined chlorine.
87. Total dissolved solids (TDS) - A measure of all the solids dissolved in the pool water measured in mg/l
88. Trichlor Trichloroisocyanuric acid (also called Symclosene) - a type of stabilised chlorine usually in tablet form.
89. Trihalomethanes - Compounds formed by reaction between chlorine or bromine and humic acid and other contaminants.
90. Turbidity Cloudiness, murkiness or lack of clarity in water caused by colloidal or particulate matter in suspension.
91. Turnover period - The time taken for a volume of water equivalent to the entire pool volume to pass through the filtration and circulation system once. The shorter it is, the more frequent and thorough the water treatment.
92. Ultra-violet light (UV) - Used as a point source non-residual disinfectant and to reduce chloramines.

16 ANNEX A

16.1) The Law

This section is provided to aid awareness and understanding. It looks at the legislation and court judgements that affect safety and outlines your responsibilities under the law. References in this chapter are to legislation for England and Wales. There are differences in the legislation in Scotland (also covered here).

Someone injured through your negligence can bring an action for damages against you in a civil court of law. If you are found negligent, you may be ordered to pay compensation for loss of earnings, medical expenses, pain, suffering and the like.

Claims for damages after accidents are perceived to be on the increase, with solicitors and accident claim practitioners touting for new business by offering no win no fee terms. Concern about the growth of the compensation culture led to the introduction of the Compensation Act in 2006. This brought in changes to the law on liability and breach of statutory duty aimed at tackling perceptions that can lead to a disproportionate fear of litigation and risk-averse behaviour. Despite this, Lord Young states in his 2010 report Common Sense, Common Safety, the problem of the compensation culture prevalent in society today is one of perception rather than reality. The number of claims for damages due to an accident or disease has increased slowly but nevertheless significantly over recent years. Furthermore, there is clear evidence that the public believes that the number of claims and the amount paid out in damages have also risen significantly.

Not only organisations but also individuals can face prosecution in a criminal court for not complying with legal duties imposed by government legislation. You can be fined, or even face imprisonment, if found guilty in a criminal court.

16.2) Criminal Law

Health and Safety Legislation

Health and Safety at Work etc. Act 1974

A criminal offence will arise from a failure to comply with legal duties imposed by the Health and Safety at Work etc. Act 1974 (HSWA) and regulations made under it.

This legislation places a duty on employers to ensure, as far as is reasonably practicable, that in the course of conducting their undertaking, employees and members of the public are not put at risk.

The phrase ‘conducting their undertaking’ also includes cleaning, maintenance and repair of the plant, machinery and buildings necessary for carrying on the business. The employer cannot delegate responsibility for this duty. Therefore, in effect, you need to consider the consequences of the actions of contractors as well as your employees.

You need to consider the cost and effectiveness of any precautions that you can take to minimise risk of harm. If a precaution is cheap, easy to take and is very effective, then it is reasonable to implement it even if the risk of harm is small. If the risk of harm is great, then more expensive precautions may be reasonable.

16.3) Enforcement of health and safety legislation

Responsibility for the enforcement of health and safety legislation rests with the Health and Safety Executive (HSE) and local authorities. Their inspectors have powers to investigate incidents and complaints or carry out routine inspections. When there has been a breach of health and safety law the enforcing authority can serve improvement or prohibition notices or prosecute.

The local authority will be the enforcing authority for most privately owned pools whereas the HSE is responsible for public pools.

Where an offence is committed with the ‘consent, connivance or neglect of any director, manager, secretary or other similar officer’, that person may be guilty of an offence along with the organisation. If the breach in the law results in death, the police are involved and they may refer the case to the Crown Prosecution Service.

16.4) The Corporate Manslaughter and Corporate Homicide Act 2007

This created a criminal offence of corporate manslaughter in England, Wales and Northern Ireland and corporate culpable homicide in Scotland. This Act applies to all companies, most government bodies, partnerships, trade unions, employers’ associations and incorporated charities. Crown immunity has been largely abolished. The Act does not apply to unincorporated bodies such as some charities, friendly societies etc., or individuals.

Corporate manslaughter and corporate homicide investigations are led by the police. They can be lengthy and intrusive. The existing provisions of the HSWA still apply.

16.5) Control of Substances Hazardous to Health Regulations 2002 (as amended) (COSHH)

Chemicals and microorganisms that may cause ill health are subject to the Control of Substances Hazardous to Health (COSHH) Regulations 2002 (as amended). These Regulations require an employer or self- employed person to:

- Assess the risks to employees, self-employed people and the public from exposure to hazardous substances, including micro-organisms.
- Prevent, or, where this is not reasonably practicable, adequately control exposure to the hazardous substances.
- Introduce and maintain control measures.
- Inform, instruct and train employees about the risks and precautions to be taken.
- Inform visitors about the risks and precautions to be taken.
- Regularly review the assessment and the effectiveness of control measures.

16.6) Management of Health and Safety at Work Regulations 1999 as amended

The Management of Health and Safety at Work Regulations 1999 require you to carry out risk assessments to identify hazards and take any necessary steps to reduce the risk of an incident. Regulation 3(1) (b) states: Every employer shall make a suitable and sufficient assessment of-

a) The risks to the health and safety of his employees to which they are exposed whilst they are at work;

b) The risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking

In effect (b) means that your risk assessments should consider the risks to visitors you invite onto your property, or other people who might be affected by your undertaking or your activities.

Regulation 5 states:
'Every employer shall make and give effect to such arrangements as are appropriate, having regard to the nature of his activities and the size of his undertaking, for the effective planning, organisation, control, monitoring and review of his preventive and protective measures.'
Where the employer employs five or more employees, the arrangements should be recorded.

16.7) Reporting of Injuries, Diseases and Dangerous Occurrence Regulations 1999 (RIDDOR)

You are legally bound under RIDDOR to report within 7 days certain accidents, dangerous occurrences and types of ill health to the enforcing authority. They may well send an inspector to investigate. The authority will also investigate complaints made by members of the public. It is essential that you are able to demonstrate that you have effective procedures in place to identify and manage risk.

16.8) Public Health legislation

The Health Protection Regulations 2010 (England & Wales) apply
Where voluntary cooperation to avert a health risk cannot be secured and where other methods of control are ineffective, unsuitable or disproportionate to the risk involved.

The Department of Health has published guidance that was written by Public Health England and the Chartered Institute of Environmental Health, which describes how these powers should be used. [link/ref?]

Powers that impose restrictions or requirements are conditional. The local authority makes an application to a magistrate who must be satisfied that the relevant criteria are met. The criteria cover evidence of infection or contamination, assessment of the potential for significant harm to human health, risk of spread to others and necessity for action to be taken in order to reduce or remove that risk. The legislation also contains various safeguards for people who might be subject to the legal measures.

The measures are contained in the Public Health (Control of Disease) Act 1984 (as amended) together with the Health Protection (Local Authority Powers) Regulations 2010 and the Health Protection (Part 2A Orders) Regulations 2010.

16.9) Civil Law

The foundation of most personal injury actions is in proving negligence under common law. An action for damages is brought in the civil courts.
To win an action and be awarded compensation the injured person must be able to demonstrate that they were owed a duty of care, and there was a breach of that duty leading to the injury.
A civil case can also be brought for breach of statutory duty that results in injury or

ill health.
Common law duties essentially derive from decisions made by judges over the years. Under common law you owe someone a duty of care if there is:

- Sufficient proximity between you and the person injured, and it was
- Reasonable to foresee that harm may result from your actions, and
- It is fair, just and reasonable to impose a duty of care on you.

Proximity can be geographical, contractual, or through a care relationship (for example between teacher and child). If you breach that duty of care, and foreseeable physical or psychological damage results, then you are liable to negligence. Employers may be held liable for the negligence of their employees (this is called vicarious liability).

Visitors must take reasonable care for their own safety. If they don't and come to harm, then their 'contributory negligence' would lessen any claim against you.
Note that children cannot be expected to appreciate dangers in the same way as adults. It is highly unlikely that contributory negligence could be attributed to the actions of a very young child. Adults, however, will be expected to exercise responsibility for children in their care.

In civil law, the duty of care has been further defined by legislation.
Under the Occupiers' Liability Acts of 1957 (OLA57) and 1984 (OLA84), the occupier of premises owes a duty of care to lawful visitors (OLA57) and trespassers (OLA84), by reason of the state of the premises and things done or omitted to be done on them. In Scotland, a similar duty of care is owed under the Occupiers' Liability (Scotland) Act 1960.

The 'occupier' is the person or body that has sufficient control over the premises to be in a position to take the steps necessary to protect people who otherwise may be at risk.
If there is more than one occupier, each owes a duty of care that is in relation to the degree of control each has over the premises.

An occupier has the duty of care and cannot delegate this duty to someone else. So, in effect, you may be responsible for the actions of contractors working on your behalf.

Visitors

Under Section 2(2) of the OLA57, the occupier has:
'A duty to take such care as in all the circumstances of the case is reasonable to see that the visitor will be reasonably safe in using the premises for the purposes for which he is invited or permitted by the occupier to be there.'

- You must consider the particular needs of people you invite onto your property.
- You must be able to demonstrate that your precautions are reasonable in the circumstances.
- You must be prepared for children to be less careful than adults. Furthermore, a warning sign, however clear in itself, cannot warn if the child is unable to read. However, in some circumstances, particularly in the case of a young child, the parent may hold the primary duty of care.

Warning a visitor of dangers might be sufficient to absolve you from liability, but only if it was sufficient to enable the visitor to be reasonably safe.

Under OLA57, you can choose to restrict or exclude your liability by imposing entry conditions. However, the Unfair Contract Terms Act 1977 says:
‘A person cannot by reference to any contract term or to a notice exclude or restrict his liability for death or personal injury resulting from negligence.’
In the case of other loss or damage, liability can be excluded or restricted only if the terms are reasonable.

17 ANNEX B

17.1) Model Pool Technical Operational Procedures

What a pool technical operational procedures look like:

1. Statement of policy

For example

Our intention is to always provide a swimming pool technical operation that is safe, healthy and environmentally friendly. We shall maintain compliance with the PWTAG Code of Practice and where relevant other national and European standards

2. Management system

The person responsible for writing and reviewing the PTOP for this pool is………

We carry out a formal review of our written plan on an annual basis and or whenever we carry out major adaptations or if there is a notable incident affecting pool water safety

We provide training and qualification for the key staff at the pool which is always maintained within currency requirements and /or employ certified personnel to undertake key roles as essential to comply with PWTAG Code of Practice

3. Staff structure and responsibilities

For this pool we always ensure that a Swimming Pool Technical Operator is on duty during all hours of the pools operation

4. Description of pool(s) and operation

25m x 12.5m public pool with 12.5 X 8m teaching pool open to the public from 7am to 10pm Monday to Friday and 7am to 8pm Saturday and Sunday 50 weeks of the year

5. Schematic of swimming pool system and key indicators

Our simple schematic plan of the pool is attached Key indicators

Medium rate sand filters

100 % surface water removal Turn over period 3 hours

Maximum capacity bathers 100 bathers Disinfection is Sodium Hypochlorite

pH correction is CO_2

6. Normal operational procedures for the pool water, heating and ventilation plant

Nb include the relevant clauses of PWTAG CoP sections 3 to 14

For example:

6.1 Water Treatment

The water treatment system for the pool is based upon PWTAG requirements, European and national standards and takes into account

- Public health hazards
- Mains water quality and storage, dilution and drainage, coagulation, filtration and disinfection
- The size and type of pool, bathing load, circulation rate, circulation hydraulics and turnover period
- Pool operation, water treatment system and plant room.

6.2 Public health hazards

Our risk assessment for this pool considers the following hazards:

- Death through drowning, including hair and limb entrapment
- Neck and head injuries from diving into shallow water or hitting other swimmers
- Injuries from falls, slipping, etc.
- Ingestion of pool water containing pathogens including the protozoal parasites Ccryptosporidium and Ggiardia that can cause gastroenteritis
- Contact with contaminated water, especially in contact with open wounds
- Inhalation of aerosols containing hazards e.g. Legionella species in distributed water, such as when using showers, but also from water jets and indoor fountains
- Skin infections of the feet, including warts, verruca's and athlete's foot
- Possible exacerbation of asthma due to excessive disinfection byproducts in the air
- Illness from water contaminated by chemicals
- Potential drowning where cloudy water prevents surveillance of swimmers under the water
- Cuts and abrasions due to sharp edges, cracked tiles etc.

6.3 Mains water quality

Our water treatment system takes into account the mains water characteristics

6.4 Pool water clarity

We monitor pool water quality to ensure no danger to bathers

6.5 Primary disinfection

Our primary disinfection is sodium hypochlorite which is monitored and dosed automatically.

6.6 Secondary disinfection

This pool uses UV to help prevent the threat from Cryptosporidium and to limit combined chlorine. The system installed and dosed in accordance with PWTAG requirement

6.7 Dilution with fresh water

We replace pool water with fresh mains water as a regular part of the water treatment regime with up to 30 litres per bather according to pool bather usage.

6.8 Bathing load

The maximum bathing load (number of bathers) allowed for at any one time is……………

6.9 Turnover period

The turnover period for this pool is ……………………..

6.10 Dye testing

This pool was dye tested when first commissioned

6.11 Water circulation

This pool operates the water treatment system continuously

6.12 Surface water removal

This pool uses a deck level surface water removal system and bottom drains. 80% of the water removal is from the surface

6.13 Inlets and outlets

Inlets and outlets, grilles and covers are in accordance with BS EN 13451-3. They are 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 is suspended immediately.

6.14 Filters and filtration rate

This pool uses medium-rate pressure filters; with sand as the main filter medium.

6.15 Serviceable filters

The filters are designed in accordance with PWTAG requirements

6.16 Annual inspection

The filters are inspected annually for corrosion and problems with the filter medium

6.17 Backwashing

Filters are backwashed at least once a week and whenever the pressure loss across the filter media bed reaches the level specified, at the end of bathing for the day.

Our filters have flow meters fitted between the circulation pumps and filters to monitor the system's flow rate during normal operation, and backwashing rate.

6.18 Coagulation

We dose PAC continuously, at a rate of 0.1ml/m3 of the total flow rate.

6.19 Bather hygiene procedures

We have notices at reception saying that bathers:

- With infections should not use the pool
- With diarrhoea must not swim – then, or for 48 hours afterwards.
- Who have been diagnosed with cryptosporidiosis must not swim for 14 days after diarrhoea has stopped.

6.20 Pre-swim hygiene

We provide pre-swim showers and toilets en-route to the pool and encourage everyone to use them before swimming. Hand washbasins with liquid soap and hand-drying facilities are provided. Staff and notices enforce all operational procedures including when not to use the pool during and after diarrhoeal illness.

6.21 Babies and very young children

We have special periods when babies and very young children are encouraged to use the pool. We insist that babies use appropriate swim wear to help prevent faecal release in the pool and provide excellent baby changing facilities.

6.22 Pool cleaning - equipment and surfaces

All floors in the pool hall area, changing rooms, toilet and shower areas are thoroughly cleaned each day. We ensure that floor-cleaning materials do not enter the pool water

6.23 Showers

Showers comply with HSG 274 part 2 The control of legionella bacteria in hot and cold water systems and are cleaned and descaled in accordance with HSG 274 part 2 requirements

6.24 Pool covers

Pool covers are checked regularly for any contamination and cleaned as necessary with 100mg/l chlorinated water

6.25 Pool equipment

All equipment is checked to ensure it is hygienic and clean before being used in the pool.

6.26 Transfer channels

Deck-level transfer is cleaned as required, at least once a month.

6.27 Balance tanks

Balance tanks are inspected at least once a year and cleaned as necessary.

6.28 Pool bottom

The pool bottom is kept clear of contamination, algae, and general debris by daily sweeping, suction cleaning.

6.29 Monitoring water quality

We have documented procedures for testing the pool water, which follow the guidance of PWTAG and the kit instructions, and operators are given full training in their use for monitoring pool water quality. The documented procedures include detail actions for operators to take if there are unexpected test results, especially if they show the pool water chemical composition is either below or exceeding safe limits.

We test the water chemically every 2 hours and the target levels for pH and disinfection are pH7.0 to 7.4 Free chlorine 0.5mg/l to 1.0mg/l

Combined Chlorine nil or up to a maximum of 0.5mg/l

On a weekly basis we test the water for balance and chemical levels Alkalinity between 80 and 200mg/l

TDS no more than 1000 above the source water Calcium hardness between 75 and 150mg/l

Automatic monitoring of chemical levels

The readouts from the controller are checked daily against the results from manual tests of the sample cell. The manufacturers’ recommendations for the calibration of the equipment, including the use of suitable test solutions, are followed. Records of all calibration tests and results are recorded on log sheets and retained.

pH

Readouts from the controller are checked daily against the results from manual tests of the sample cell. If the difference is more than 0.2, the controller is recalibrated

Disinfection

Readouts from the controller are checked daily against the results from manual tests of the sample cell. If the difference is more than 15%, the controller is recalibrated after first confirming the result with a further manual test.

6.30 Microbiological testing

The swimming pool is microbiologically tested each month to monitor for the presence of potentially harmful microorganisms by the following ………………………….. UKAS-accredited laboratory.

Tests are also done

- Before it is put back into use, after having been shut down e.g. for repairs
- If there are difficulties with the treatment system
- If contamination has been noted
- As part of any investigation into possible adverse effects on bathers' health.

The required microbiological conditions are in accordance with the PWTAG Code of Practice

6.31 Acting on failures/pool closure

Step 1 If a result is unsatisfactory, a preliminary investigation is undertaken and the test repeated as soon as practicable.

Step 2 If the second result is also unsatisfactory, we investigate further and the test repeated.

Step 3 If the third result is still unsatisfactory, we take immediate remedial action

6.32 Plant room

The plant room is a secure area not accessible by unauthorised persons. It is not used for general storage, or for storing hazardous chemicals, unless chemicals are in containment structures or devices designed to control spillages with adequate separation from other chemicals and substances stored in the plant room;

Plant, including electrical equipment is inspected and maintained in accordance with a planned programme.

6.33 Safety systems provided and maintained

Relevant safety systems and safety equipment and personal protective equipment is held in the plant room, maintained in accordance with a planned programme. Monthly inspection of personal protective equipment is carried out to check its continuing suitability.

6.34 Confined spaces

Staff are not permitted to work in confined spaces

6.35 Chemical safety – COSHH

Pool management ensure a competent person assess the risks associated with hazardous substances in the workplace and that we put in place procedures to eliminate or control those risks.

These procedures are systematically recorded to include:

- Identification of the hazards
- Disinfection and pH chemicals
- Identification of who might be harmed and how
- Swimming pool technical staff
- Evaluation of the risks arising from the hazards, and decisions about precautions
- Based upon the Safety Data Sheets
- The findings are recorded here
- Sodium Hypochlorite
- CO2
- PAC
- Cleaning materials
- We carry out regular review of the assessments and make necessary revisions.

We ensure SDSs are provided and available for all the chemicals in the plant room including pool chemicals, cleaning chemicals, pool water testing chemicals and chemicals used in maintenance programmes.

6.36 Training in chemical handling

We provide all staff involved in the handling and use of chemicals with appropriate training and instruction.

6.37 Personal protective equipment (PPE)

Pool management take the advice of suppliers about what PPE is needed and ensure that this is provided and maintained:

Gloves

Overalls

Goggles

Foot wear

Respirators

6.38 Chemical spillage

Any spillage is cleared away using a safe method agreed between chemical supplier and pool operator. The method is displayed on a notice, together with the provision of the necessary equipment and its location.

6.39 Safety information on site

Precaution cards and first aid instructions are displayed for each chemical.

6.40 First aid

First aid provision including equipment for dealing with the consequences of direct contact with chemicals is provided which includes.

- Eyewash facilities should be located in close proximity to the hazard to enable immediate action.
- A wash-basin with running water should be provided in case chemicals come into contact with the skin or eyes.

6.41 Delivery of chemicals

Everyone involved in the transport, handling and storage of pool chemicals receives initial and refresher training in the procedures involved

Deliveries proceed only when a trained staff member is available to receive and check the materials.

6.42 Bulk delivery of sodium hypochlorite and hydrochloric acid

There are documented procedures for transfer and handling during delivery. Suppliers help to establish and must comply with these procedures.

Pipework is clearly labelled and specific to the delivery of that product, Pipework fill points are clearly labelled and locked when not in use.

6.43 Transport from offloading area to store

Chemical containers are taken to a suitable storage area as soon as possible; not left unattended in an offloading area; are kept upright and never rolled; and are used in stock rotation.

The method of handling chemical containers is described in these procedures and staff informed and trained in these.

6.44 Chemical store

Chemical stores are kept clean and dry for the storage of solid materials, protected from sunlight and hot pipework or plant. Chemical stores have warning signs, are secure and accessible only to authorised, appropriately trained people.

6.45 Dosing

Hand dosing in normal operation is not permitted at this pool

6.46 Chemical dosing operations

Written procedures are provided for day tank filling, mixing or diluting chemicals and cleaning injectors.

Chemical dosing systems monitors and automatic controls are interlinked with the circulation pumps and the circulation of water through the system, so that dosing stops if there is pump failure or significant loss of pumping rate. These systems are designed to always fail to safety and require manual restart when circulation is restored.

6.47 Chemical line safety

All chemical pipework, suction lines, delivery lines and tanks is marked to identify the contents and the direction of flow.

All pipes used for delivery of chemicals to injection points are double sheathed.

Disinfectant and pH dosing systems are kept separate.

Dosing sets are separated in individual bunds.

6.48 Preparing dosing chemicals

Chemicals are added to water and never the other way round when preparing solutions. Non-liquid chemicals are kept dry until dissolved in water.

6.49 Heating and air circulation

This pool maintains the following temperatures

Pool use	Temperature range (°C)
Competitive swimming and diving, fitness swimming, training	26-28
Recreational swimming and adult teaching	27-29
Leisure waters	28-30
Children's teaching	29-31
Babies, young children, disabled and infirm	30-32

6.50 Pool hall air

The pool hall air temperatures are maintained at no more than 1deg C above or below that of the water temperature. Air temperatures over 30°C are not permitted.

Relative humidity is maintained at a level of 60% (no less than 50%, no more than 70%) throughout the pool hall area.

Ventilation systems are designed and operated to provide a level of fresh air for each occupant of the pool hall (bathers, staff and spectators).

7. Emergency Procedures for pool water, heating and ventilation plant

Nb include the relevant clauses of PWTAG CoP sections 3 to 14 For example

7.1 Faecal accidents and Cryptosporidium

This pool has a written agreed procedure for dealing with faecal fouling which follows the guidance on the PWTAG website and in the Code of Practice

7.2 Blood and vomit pool water contamination

If significant amounts of blood are spilled into the pool, it is temporarily cleared of people, to allow the pollution to disperse and any infective particles to be neutralised by the residual disinfectant. We then confirm that disinfectant residuals and pH values are within the recommended ranges and bathing can then resume.

7.3 Contamination of pool surround

Any blood spillage on the poolside is dealt with using strong disinfectant – of a concentration equivalent to 10,000mg/l of available chlorine. The blood is covered with paper towels, gently flooded with the disinfectant and left for at least two minutes before it is cleared away.

7.4 Vomit in the pool

Our procedures for vomit in the pool and vomit on the poolside are the same as when dealing with blood.

7.5 Pool closure and Microbiological contamination

We close the pool immediately if there is chemical or physical evidence of unsatisfactory disinfection e.g. poor clarity or low free chlorine concentration.

The pool is closed if microbiological testing indicates gross contamination, which means one of two things:

1. E. coli over 10 per 10 ml PLUS either colony count over 10 cfu per ml or Pseudomonas aeruginosa over 10 per 100ml (or, of course, both)
2. Pseudomonas aeruginosa over 50 per 100ml PLUS colony count over 100 per ml.

7.6 Toxic gas leaks

There is an emergency action plan for dealing with any major release of toxic gas.

The procedure includes Safety of staff and customers arrangements for any necessary evacuation co-ordination with emergency services, who are consulted in the preparation of this plan.

8. Records and logs

For example

- Daily swimming pool water log

- Monthly bacteriological log
- Swimming pool water incident log and faecal accident log
- Automatic monitoring calibration
- Monthly inspection of safety equipment and PPE
- Staff training in handling chemicals
- Staff training in pool water testing

18 ANNEX C Dye test

[New requirements to come from BS EN 15288]

The pool water is first de-chlorinated using sodium thiosulphate pentahydrate or equivalent.

1. Any ozone treatment plant or carbon filters are bypassed (and the flow rate restored to what it was before the bypass); other filters not bypassed should be clean.
2. There are a number of different dyes used, and the precise nature of the test will be affected by that choice. Eriochrome black T (solochrome) is used dosed at 0.2g/m3 of pool water; potassium permanganate is dosed at 0.3g/m3 (UV as well as ozone treatment plant should be by-passed if permanganate is used).

   The dye is dosed for 5-10 minutes. It is added to the pool close to the chlorine dosing point, usually through a chemical dosing pump or strainer box.
3. The time taken for the pool water to become evenly coloured gives a first measure of the adequacy of the distribution system. This should be achieved within 15 minutes for the result to be satisfactory.
4. Once the colouration of the pool is completed, the dye should be removed without delay using chlorine, ozone or equivalent. As well as avoiding any staining, this addition initiates the second part of the test. 5mg/l of chlorine should clear the dye colour in 15 minutes to confirm the test result.

19 ANNEX D - Hair entrapment test

1. A hair probe is made of 50g of natural or of a good quality synthetic, both medium to fine, straight, 400mm in free length. The hair probe shall be in good condition; tangle free and the end of single strand may not be jagged.
2. One side of hair probe is attached to a rod of 25 to 30mm diameter. The rod should be at least 300mm long.
3. A dynamometer with an accuracy of 0.5N, to determine the traction force against the entanglement, is needed.
4. For the on-site test, the pool has to be in full operation. The test may be carried out from basin edge, water surface or by diving or robotic equipment.
5. Saturate the hair for at least 2min in pool water. After being saturated, place the free end of the hair approximately 300mm in front of the device and above the uppermost surface of the face of the device
6. Slowly move the hair ends closer to the device and feed the highest possible quantity of hair ends into the device itself in the direction of the intake flow. Continue to feed the hair slowly by moving the rod from side to side while shortening each pass for at least 60 seconds until ideally at least 50% of the length has been sucked in. In any case a length suitable to detect the presents of turbulence behind the grille has to be fed in. Then lay the rest of the hair against the device, in such a way that the hair remains in contact with it for at least 30 seconds.
7. The surface of the device is divided into areas of about 50 x 50cm. In the centre of each area and additionally above the pipe, where the water speeds is highest, one test is done. If the hair does not get sucked into the sump the test is passed. With the pump still operating, test the pulling force necessary to free the hair from the device. Measure the force of entanglement.
8. Repeat the test three times for each area. For devices with perforated plates, grilles (e.g. with a larger surface) move the free end of the hair over and against the whole surface. Detect if the hair probe gets sucked.
9. If one device serves more than one attraction, the test is done at the maximum of the possible flow rate. 10 Brush hair periodically, to keep tangle-free.

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