Queensland Health Swimming and Spa Pool Water Quality and Operational Guidelines

Queensland Government
Queensland Health

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Introduction

Australians, in particular Queenslanders, have long enjoyed recreational pursuits that involve water. The municipal pool is where a lot of young Queenslanders took their first steps in learning to swim.

Queensland, because of its position in the tropical and temperate zones, has a wide variety of climatic conditions prevailing at any one time. Because of the differing climatic conditions and water types throughout Queensland, the operator needs to consider local conditions (eg. higher average daily temperatures, chemical content of the reticulated water), when operating the facility. In tropical Queensland, the water temperature is likely to be above 26^0 C for most of the year.

The good management of swimming and spa pools ensures that patrons are not subject to health risks. The prevailing climatic conditions can adversely affect water quality through the action of the sun and rain in particular. In swimming and spa pools that contain reduced levels of or no disinfectant, the potential exists for the rapid growth of micro-organisms. Similarly swimming and spa pools that contain warm water face the same situation.

These guidelines have been developed to provide a basis for the safe operation of swimming and spa pools in Queensland. They have been developed in conjunction with representatives from Queensland Health's Public Health Unit Networks, Brisbane City Council, Department of Natural Resources and the Swimming Pool and Spa Association of Queensland.

Pool operators are encouraged to undertake one of the pool operator courses available. The courses provide guidance on the types of equipment used, problems which may arise during daily operation, basic chemistry of the pool water and are a good source of reference material.

There is no specific legislation in Queensland regulating the operation of pools and spas, however, some local governments have local laws which may be relevant. A model local law on swimming pools is available from the Department of Communication and Information, Local Government and Planning. Apart from any statutory requirements, operators of pools, especially those that are used for commercial purposes, need to be aware of their Duty of Care obligations to provide a safe swimming environment. Workplace, health and safety issues arise for situations where the pool is part of a workplace, and indeed the Workplace, Health and Safety Act should be consulted. Operators should have a sound knowledge of first aid and resuscitation techniques. Various institutions such as the Royal Life Saving Society of Australia, St Johns Ambulance and the Red Cross offer life saving and/or first aid courses.

Queensland health swimming pool and spa pool water quality and operational guidelines

There has been a proliferation of swimming pools, spa pools and specialist pools both public and private in recent years. The popularity of pools, such as hydrotherapy pools and birthing spas, has increased to a point where that is an accepted use for a pool. Disinfection of swimming and spa pools focuses on the need to provide a safe water environment for public activities. The water in the pools should be safe and not cause harm to the public, have a residual of disinfectant to cater for shock loads of micro-organisms and organic matter and the pool should be able to be operated in a continuous manner with no risk to the public.

Scope

These guidelines set out recommended water quality standards and operational standards for swimming and spa pools in Queensland to ensure safe bathing water is provided for users. It is intended to compliment the Code of Practice for the Control of Cryptosporidium and Giardia in Swimming, Leisure, Hydrotherapy and Spa Pools produced by Queensland Health in December 1998. There are many existing guidelines covering the design, selection and safe pool operation for swimming pools and spas including:

- SAA HB65-1998 Standards Australia - Residential swimming pools - selection, maintenance and operation
- AS 2610.1-1993 Spa Pools Part 1: Public Spas
- AS 3979 - Hydrotherapy Pools
- AS 3633 - 1989 Private Swimming Pools – Water Quality
- SAA HB112-1998 Residential spa pools selection, maintenance and operation
- Guidelines for Safe Pool Operation - The Royal Life Saving Society Australia
- Choosing your pool and spa in Queensland - Swimming Pool and Spa Association of Queensland
- Code of Practice for the Control of Cryptosporidium and Giardia in Swimming Pools, Leisure Pools, Spas and Hydrotherapy Pools - Queensland Health 1998
- National Environmental Health Forum – Guidelines on water quality for heated spas – Water Series No 2
- Shade for Public Pools – Planning Sun-Safe Outdoor Environments in Queensland, Queensland Health
- Breakpoint Chlorination of Swimming Pools – ORICA WaterCare.
- Various State Publications eg. NSW Health - Public Swimming Pool and Spa Pool Guidelines June 1996

The Swimming and Spa Pool Water Quality and Operational Guidelines apply to:

- public swimming and spa pools
- wading and receiving pools associated with water slides
- wave pools
- hydrotherapy and therapeutic exercise pools

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that are open to the public and include pools located at:

- municipal and commercial sites
- schools
- hospitals
- hotels and motels
- leisure centres, health resorts, gymnasiums, clubs and resorts
- camps, caravan parks
- community health centres
- retirement villages or on common properties such as strata title or cluster title units.

They are not intended to apply to:

- private pools and spas
- natural bodies of water.

The guidelines were not developed for regulatory purposes, nor is strict compliance intended but rather they may be used as an arbitrary tool to assess the suitability of the water body for recreational use over an extended period of time.

Types of pools

The National Health and Medical Research Council guidelines for recreational use of water, primary contact recreational, should be used when assessing untreated waters used for recreational purposes. These apply to all open waters, both fresh and saline, as well as marine and estuarine waters.

Swimming and spa pools fall into one of the three following categories of disease transmission - high, medium or low risk.

To determine whether a swimming or spa pool falls into one of the categories, the operator needs to assess the bather load, level of environmental contamination likely, the climatic conditions (eg. temperature) and the health status, if known, of the bathers using the pool. It is possible for a pool to be high risk during the warmer months and low risk during the winter months. The risk of the water quality being affected by a combination of these factors needs to be addressed by the operator to determine the monitoring regime which should apply to the pool. The higher the risk of disease transmission for the pool, the more increased monitoring requirements apply. Essentially a swimming or spa pool which has balanced water, which meets the chemical criteria outlined in the chemical parameter table (page 8) will be relatively free from pathogenic organisms.

High risk swimming and spa pools require greater operator supervision and water chemistry testing than medium or low usage swimming and spa pools. Most of the supervisory systems should be automated. It is expected that the operator or the appointed responsible employee keep extensive records. It is proposed that pool water

chemical tests are carried out five times per day and spa pools five times per day or after heavy use. A pool log, similar to the one in the back of these guidelines, should be used for recording test results. (See page 22 for details).

Medium risk swimming or spa pools require less supervision, but a similar water chemistry-testing regime as a high usage swimming or spa pool should apply. Water chemical tests should be carried out three times a day and it is recommended that a pool log, similar to the one in the back of these guidelines, be kept.

Low risk swimming or spa pools require minimum daily supervision and operator testing. Minimum records need to be kept. A record of all daily tests is advisable as there may be a turnover of residents or operators charged with the responsibilities for the swimming or spa pool. Water chemical tests should be carried out twice daily or after heavy usage for both swimming and spa pools. A pool log, similar to the one in the back of these guidelines, should be used for recording test results.

High risk swimming or spa pools are more likely to be contaminated with a greater diversity of disease causing organisms than low usage swimming or spa pools, because they are open to community contamination. Disease causing organisms may be introduced from many sources but are mainly associated with bathers. These organisms may be brought into a pool on the bathers skin, and through their saliva, urine and faeces. The organisms may also be introduced from dust, birds droppings, make-up water and soil carried on bathers feet. Some of these disease-causing organisms live and may even grow in pool water unless the pool water is adequately filtered, and properly and continuously disinfected.

The swimming or spa pool needs to be designed and operated to enhance the action of the disinfectant. It is recommended all swimming and spa pools, to which these guidelines apply, be equipped with an effective water circulation system, a filtration system, and should have a continuous disinfectant dosing control system. Continuous dosing does not include the use of a floating dispenser containing a disinfectant as this is often removed when the pool is in use.

Spa pools

Spa pools should be drained at least once per month to enable cleaning procedures to be undertaken. There can be a build up of acid in the spa pool and this requires an exchange of water to reduce the level. Before draining a spa pool, contact the Local Government or Environmental Protection Authority for information on approvals to discharge and dispose of waste material from the filter cleaning process. The spa may have significant levels of chemicals, which may need to be neutralised prior to discharge. The cleaning program should include the filter (often of the cartridge type) as well as the spa itself. It may also be useful to have a replacement cartridge while thorough cleaning of the cartridge takes place. Thorough cleaning includes removal of lint and foreign matter, and soaking overnight in 10 ppm chlorine or similar disinfectant. Cartridge suppliers do not have a recommended method of cleaning the cartridge other than by hosing. The operator, who is guided by the level of accumulations on the cartridge and the state of the cartridge itself, should determine the method used. All accumulations on the surface of the cartridge should be removed as matter adhering to the cartridge

surface may harbour bacteria. A barrier can be formed to protect the bacteria from disinfectants used in the spa pool. The spa pool should be designed with a weir offtake or skimming system that will continuously take water from the pool surfaces.

Spa pool water temperature

Where spa pools are heated, the temperature must never exceed $40^{O}C$ and exposures at greater than body temperature should not exceed 20 minutes for a healthy adult. Signs should be displayed restricting bathing to 20 minutes. The temperature of the spa should be regularly checked. Temperature has an adverse effect on the killing power of disinfectants, such as chlorine, in that the disinfectant dissipates rapidly. Warmer temperatures favour bacterial growth, such as *Legionella* in filter media, which may be transmitted by aerosols in spa pools. *Pseudomonas aeruginosa* survival and growth is enhanced at temperatures exceeding $26^{O}C$.

Pool plant and turnover rates

A swimming pool filter plant should be designed to have a volume turnover period (exclusive of balance tanks) of five to six hours. Filtration systems should run to ensure the water is clear and water chemical levels outlined in the table are achieved prior to the first patrons using the pool. 24-hour facilities should have continuous filter operation. The pool plant for public pools should provide continuous dosing of disinfectant and continuous filtration while the plant is in operation. A balance tank should be considered in the design of pools where the depth exceeds 1 metre. Spa pools should be connected to a filter system dedicated solely for the spa to enable a turnover rate of once every 20 minutes. Wading or children's pools should also have a separate filter system. Generally accepted turnover rates include spa and bubble pools 20 minutes, pools < 0.5 m deep 30 minutes and pools > 3.0 m deep five hours.

Hydrotherapy pools

Persons who use hydrotherapy pools may have a variety of conditions that may be transmitted by the pool water if the pool is not properly maintained. They can be more difficult to maintain than other pools due to the higher water temperature favouring the growth of bacteria and the water turbulence of the spa that assists in the dissipation of the disinfectant used. The temperature should be between $28^{0}C$ and $35^{0}C$. Turnover rates for hydrotherapy pools should be less than two hours. Guidance for hydrotherapy and spa pools in health care facilities are contained in Queensland Health's Infection Control Guidelines – June 1999 and Australian Standard AS3979-1993 Hydrotherapy Pools.

Breakpoint chlorination

In swimming and spa pools the bacterial count is controlled by the addition of a disinfecting agent. When chlorine is added to contaminated water, it begins to react with organic matter and ammonia-like compounds, and is gradually expended. Bathers mostly introduce the ammonia-like compounds from urine contamination. The ammonia-like compounds reaction with chlorine forms chloramines. When all the chlorine in the water exists as chloramines this is called marginal chlorination. There are several types

of chloramines. The chlorine in combination as chloramines is available for disinfection and is called combined chlorination, but the speed of its disinfection is much slower than that of chlorine in a free or uncombined form.

However, if sufficient chlorine is added such that some of the chlorine exists in the free form, this known as free residual chlorination and the disinfection can be up to 50 times more effective than marginal chlorination. Adding sufficient chlorine can destroy the chloramine compounds present in the water. However, when the pool is in use, there will always be some chloramines in solution because the time necessary to destroy them. This time period will depend on a number of factors, including the amount of chloramines in the water, temperature, pH and the chlorine dosage used to maintain the free residual chlorine level. While chloramines are being destroyed, additional amounts will be formed while the pool is in use from further pollution by bathers.

By the continuous addition of sufficient chlorine at the close of the swimming session, the chloramine content will be reduced progressively. When all chloramines have been destroyed, the tests for free chlorine and total chlorine will give the same value. When this point has been reached, breakpoint chlorination has been achieved. This is the best method of ensuring that water is free of disease producing germs.
Chlorine demand is best described as the difference between the amount of chlorine applied to the water and the chlorine residual. Superchlorination is the process of adding chlorine to the water beyond the level needed to produce an initial residual.

Total alkalinity

When water is chlorinated, small amounts of acid are produced. In order to prevent the water in a swimming or spa pool becoming acidic, a total alkalinity should be maintained at all times. This is usually achieved by adding soda ash to the water. The level of total alkalinity should be maintained between 80 and 200 mg/L.

The total alkalinity is expressed chemically as the equivalent amount of calcium carbonate in the water. If the recommended level of total alkalinity is not maintained, a sudden increase in the chlorine dosage rate may cause the pH of the water to fall below a safe limit (7.2 to 7.8) and the water may become acidic.

Total dissolved solids

Total dissolved solids (TDS) is a measure of all soluble matter dissolved in pool water. Mains water often has a TDS of several hundred mg/L. All chemicals added to a pool, particularly chlorides and a sulphate, increase the TDS level and a high level is an indication of chemical overload or a lack of dilution of pool water. As a general rule, TDS should not rise greater than 1,000 mg/L above the mains water and should not be permitted to rise to an absolute of 3,000 mg/L. Regular partial emptying of the pool and refilling lowers TDS.

Filtration[1]

The clarification and purification of the pool water will not be achieved unless the water is both filtered and disinfected. Sand filters and coated mesh (or element) filters are two basic types in use.

Coated mesh (or element) filters

These can be broken into two types - diatomaceous earth and cartridge filters. Diatomaceous Earth filters consist of a set of pads or filter elements that are coated with diatomaceous earth before use. This layer is called the precoat and does the filtering. After the filter becomes dirty the precoat, with the sediment, is backwashed to the drain. This is done when the pressure builds up in the filter to a figure set by the manufacturer. A fresh precoat is applied and the filter is ready for service again. Diatomaceous earth is obtained from mining the skeletons of diatoms, minute creatures that lived millions of years ago. After cleaning, it is crushed into various grades of fineness which form a crystalline pattern to make an ideal filtration medium as it is chemically inert.

Cartridge filters come in various sizes to suit particular volumes of water. A cartridge filter usually consists of a container, which should include an automatic pressure bypass valve, and a manual release valve, in which a replaceable cartridge of porous material such as polyester or paper is fitted and sealed. The cartridge material is formed in a concertina shape to provide the maximum surface area possible. Water flows through the filter material and the dirt remains on the cartridge. The cartridge must be removed regularly and hosed clean. Acidic compounds or other chemicals manufactured for this purpose may be used to assist in cleaning a cartridge, but a chemical company or a pool professional should be consulted. A cartridge filter cannot be backwashed. The filter material does not recover 100 percent after being cleaned.

High-rate sand filters

The high-rate sand filter is a pressure tank partly filled with sand. Tanks can be made of steel, stainless steel, fibreglass and moulded plastic. Water is diffused, softening the water flow, in the filter over the top of the sand bed and through into the underdrain in the bottom of the filter tank and returned through a centre stand-pipe in the filter to the pool. The water is forced through the sand at high speed. Larger dirt particles are left behind on the surface of the sand, and finer particles are partly mechanically flocculated, that is, after passing through the sand they combine as they have been electrically desensitised. The high-rate sand filter is an excellent water filtering device. Its size depends on the volume of water and the amount of use of the pool. If the sand is backwashed regularly it will stay in good condition.

[1]sections from SAA HB112 Residential spa pools – selection, maintenance and operation, and SAA HB 65-1998 Residential swimming pools – selection, maintenance and operation.

Chemical parameters

These guidelines specify the MINIMUM chemical criteria by which a swimming pool and spa pool should be operated to minimise the public health risks to bathers to acceptable levels. It is important for people responsible for pool operation to maintain their pools at a standard equal to or greater than these guidelines at all times the pool is open to the public. The level of one chemical parameter can adversely affect another eg. if the pH is too high or too low the disinfectant properties of chlorine are decreased.

Chemical Parameters Table

	Indoor Pool	Indoor Pool (heated)	Outdoor Pool	Outdoor Pool	Spa
Water temperature		**> 26^{0}C**		**> 26^{0}C**	**35^0 - 37^0 C ideal 40^{0}C max**
Free chlorine (mg/L, ppm) minimum	**1.5**	**3**	**1.5**	**3**	**3**
Free chlorine (mg\l ppm) with cyanuric acid	**N/A**	**N/A**	**3**	**4**	**N/A**
Total chlorine (mg/L, ppm)	**free chlorine + 1 (10 max)**	**free chlorine + 1 (10 max)**	**free chlorine + 1 (10 max)**	**free chlorine + 1 (10 max)**	**10.0**
Bromine (mg/L, ppm) minimum	**3.0**	**4.0**	**3.0**	**4.0**	**4 - 6**
Ozone (for chlorine level see above)	**0 residual**	**0 residual**	**0 residual**	**0 residual**	**0 residual**
pH	**7.2 -7.8**	**7.2 -7.8**	**7.2 -7.8**	**7.2 -7.8**	**7.2 -7.8**
Total alkalinity mg/L, ppm	**80 - 200**	**80 - 200**	**80 - 200**	**80 - 200**	**80 - 200**
Cyanuric Acid	**0***	**0***	**30 - 50**	**30 - 50**	**0***

As indoor pools are protected from direct sunlight, cyanuric acid must not be used as the effectiveness of chlorine is reduced.

NOTE: Combined chlorine shall not exceed half the total chlorine concerntration with a maximum of 1.0 ppm.

Microbiological criteria

Recommended microbiological criteria for all swimming and spa pools, covered by these guidelines are listed in the table below. Routine monitoring of the microbiological quality of the water is recommended, in particular for high risk pools, see Appendix 4. Monitoring can provide a guide to the effectiveness of a given disinfection program. It is expected that the operator of a swimming or spa pool is familiar with these requirements and the adjustments that should be made to comply with the levels. It is important to note the result obtained from a microbiological water sample will be a snapshot of what was happening at the sampling time, which may be several days prior to receiving the result. The results should be compared to the bather load at the time when the sample was taken. The daily log of activity at the swimming or spa pool can be a vital tool in understanding what factors are contributing to the result obtained for the microbiological water sample.

Microbiological Criteria Table

Type of Organism	Maximum Count Allowable
Heterotrophic Plate Count	100 Colony Forming Units (CFU) per ml
Thermotolerant coliforms or *E. coli*	Nil per 100mL
Pseudomonas aeruginosa	Nil per 100mL

Appendix 1

Disinfectants/disinfection processes

To minimise the risk of infection to bathers, a disinfecting agent should be used that:

- is easily and safely applied to water
- is able to rapidly kill a wide range of disease-causing organisms
- is capable of simple on-site measurement of concentration in pool water.

An ideal swimming and spa pool disinfectant would produce two extremely important distinct effects:

- a residual bactericidal effect
- an oxidation effect.

While some disinfectants can do both, others can only disinfect or oxidise. Some disinfection processes may be bactericidal for a short time but rapidly dissipate to leave the pool without a residual protection. It is important to be able to measure the amount of disinfectant in the pool water or to be able to measure the disinfection power of the disinfectant/disinfection process. There is no ideal disinfectant/disinfection process as all have their relative strengths and weaknesses. Before a disinfectant or disinfectant system is installed, it is recommended that advice from a pool professional or consulting engineer be sought. Some local governments may require specific disinfection processes be used.

Disinfectants are only effective on surface contact. They will not penetrate scales and dirt layers, hence the importance of ensuring pool surfaces are clean.

Types of disinfectants

Chlorine

The disinfectant form of chlorine is "free residual chlorine". It is also known as "free available chlorine" or "free chlorine" and all terms refer to the concentration of hypochlorous acid and the hypochlorite ion in equilibrium concentration in the pool water. It is strong and safe when used properly and is still the most popular form of disinfection. There is extensive material available on the techniques of chlorination and “breakpoint chlorination” in particular. It is excellent practice to attain breakpoint before the first chlorine measurements are taken each day. Breakpoint chlorination means that all of the chlorine is available as free chlorine. This is achieved by adding sufficient chlorine to burn out all the combined chlorine, so that free chlorine equals total chlorine.
The higher the pH above seven the less the disinfection power of free chlorine. The disinfection power of chlorine is also reduced by a low pH. The pH needs to be properly controlled in a swimming or spa pool when chlorine is used and automatic adjustment is recommended to levels between 7.2 and 7.8. The control of pH will add life to the pool pipes and filters by preventing unnecessary corrosion or scale build-ups.

The residual chlorine can also oxidise ammonia, some other organic compounds and some organic nitrogen introduced into the pool by urine or perspiration. However, free chlorine can combine with ammonia to form compounds known as chloramines, and this reduces the ability of chlorine to disinfect particularly in indoor pools. Chloramines are also known as “combined residual chlorine” and should be kept to a minimum as they can cause eye irritation. The addition of chlorine will oxidise the chloramines over a period of time. The Australian Standard AS3633 provides further information on this.

Chlorine is available in many forms and not all forms are appropriate for all applications. Calcium hypochlorite (powdered or granular chlorine) for example should not be used in hot spas as it may promote scaling on heat exchangers and on hot water control valves which may lead to scalding. Cyanurated chlorine (stabilised chlorine) should not be used in indoor pools. Bromine may be used as a trace disinfectant to reduce the adverse effects of chlorine.

Bromine

Bromine is a weaker disinfectant than its chlorine equivalent and to achieve similar disinfection, bromine needs to be at concentrations of at least 50 per cent to 60 per cent higher than chlorine, which is recognised, in the chemical criteria of these guidelines. Bromine reacts with nitrogenous compounds in a similar way to chlorine to produce bromamines. They do not cause the serious discomfort to bathers as do chloramines. There are fewer complaints of eye irritation and obnoxious chemical related odours when bromine is used. This makes bromine more suited to indoor pools.

Bromine may be used as bromochlorodimethylhydantoin (BCDMH) or alternatively as a bromide bank system with activation by chlorine. Bromine is less stable than chlorine when exposed to ultra violet light but unlike chlorine cannot be stabilised and is therefore less suitable for outdoor pools than chlorine. A stabilised chloro/bromide system may also be considered.

As pH increases or decreases, disinfection power is lost. However, the loss of disinfection power is less than that of chlorine over the pH range of 7.2 to 7.8. There have been reported cases of skin rashes, contact dermatitis and sensitisation following prolonged exposure to high levels of BCDMH.

Saltwater chlorination (electrolysis)

Salt water chlorination is the process of electrolysis of salt water. The electrodes produce chlorine and hydrogen in gaseous form at a constant rate determined by the salinity of the pool water. It is important to maintain correct salinity levels or the chlorination production rate declines. While hydrogen may be liberated as a gas, the chlorine rapidly dissolves to form 'free chlorine' and follows the usual chlorine swimming pool chemistry, except that the chloride ion may reform and be available again for conversion in electrolysis. Salt water chlorination should operate on a continuous dosing system and a bank of electrolysis units should also be provided. As salt water

chlorination does not have the ability to respond adequately to shock loadings, super-chlorinating overnight and supplementary shock dosing with granular or liquid chlorine may be required. Shock dosing should never be done within three hours before bathers are admitted to the swimming or spa pool or while people are bathing.

Isocyanurated chlorine compounds (stabiliser*)*

Isocyanurated chlorine compounds and isocyanuric acid are used to stabilise chlorine against exposure to sunlight. Chlorinated isocyanurates when dissolved in water provide free chlorine. All isocyanurated chlorine compounds (except sodium dichloroisocyanurate) when added to water tend to lower the pH by varying amounts. The use of isocyanurated chlorine is optional.

Research on outdoor pools has shown that chlorine residuals without isocyanuric acid had lost 90 per cent of the chlorine residual on a sunny day in three hours. Pools containing 25 to 50 mg/L of isocyanuric acid under the same conditions lost only about 15 per cent of the chlorine residual. No appreciable increase in chlorine stability occurred above 50 mg/L isocyanuric acid. Indeed, laboratory studies have confirmed the benefits of pool stabilising and shown that no appreciable increase in stability occurred above 30 mg/L isocyanurate over a one hour period.

Further tests have shown that high levels of isocyanuric acid required significant increases in the level of chlorine required to achieve comparable disinfection rates. Laboratory tests using distilled water demonstrated reduced killing of *Pseudomonas aeruginosa* as the concentration of isocyanurates increased. Surveys of actual swimming pools using isocyanurates have demonstrated that concentrations of isocyanuric (up to 100ml/L) had little effect on the kill rate in the presence of ammonia and nitrogen.

An excess concentration of isocyanuric acid can be reduced only by the dilution effects of rainfall or by topping up after filter backwashing. Once the desired level of isocyanuric acid has been reached in the pool (20 to 30mg/L), the pool operator may cease using isocyanurated chlorine compounds and change to using other chlorine compounds. Isocyanurates must not be used under any circumstances in an indoor pool or indoor spa because of decreased rates of kill of some disease causing organisms and the increase in the delay of initiation of kill.

Ozone

Ozone (O_3) is an unstable blue gas with a characteristic pungent odour. It is produced commercially from clean, cool, dry air or oxygen by the discharge of high voltage (4000 to 30,000v) electricity. Ozone may also be produced as a “by product” by specific wavelength ultraviolet lamps. At air concentrations of 0.25 mg/L it is considered injurious to health. At 1.0 mg/L in air it is extremely hazardous to health.

It is a short lived, unstable but powerful oxidising and disinfection agent which does not react with porcelain or glass. Ozone disappears quickly from water. This is advantageous from the point of view that such a hazardous agent quickly disappears but disadvantageous from the point of view that no satisfactory disinfectant residual is

provided in the pool itself. Ozone may not be used as the sole disinfectant in a public swimming or spa pool but may be used in conjunction with chlorine or bromine.

Where ozone is used with chlorine, a reduction of free chlorine is permitted provided mainstream ozonation is practised and the ozone is quenched using a bed of activated carbon, preventing ozone from degassing in the pool.

Polyhexamethylene biguanide ("baquacil") and hydrogen peroxide

The disinfection system relies on the bacteriostatic properties of “Baquacil” and a fortnightly shock dose of hydrogen peroxide for oxidisation. Its recommendation as a pool disinfectant was made as a result of field trials and is accepted by the NH&MRC and overseas as a domestic pool size disinfecting system (less than 100,000 litres).

Baquacil is not well suited to handling shock loads but it does aid in the flocculation and removal of contaminants by filtration. It cannot be used in spa pools due to excess foaming. This system is **NOT** compatible with chlorine. Advice should be sought from a pool professional on its use.

Chlorine dioxide

Chlorine dioxide has the unique ability to break down phenolic compounds and remove phenolic tastes and odours from the water. It does not react with ammonia. Its oxidation-reduction potential is close to that of chlorine. Chlorine dioxide is an extremely reactive compound. Stabilised chlorine dioxide (liquid) is recommended for use not on-site generated gas. It should be kept away from acids, organic materials, reducing agents and oxidising agents.

Appendix 2

Other chemicals

There is a wide range of chemicals that may need to be used in the treatment of swimming and spa pool water apart from disinfectants. Care should be taken when making any alterations to pool water chemistry. Sudden adjustments may produce misleading readings that can severely affect the overall water balance of the pool. The manufacturer labels all proprietary chemicals used in swimming or spa pool chemicals. The label indicates the name of the chemical, the intended use of the chemical and hazards of the chemical. A Material Safety Data Sheet should be obtained for each chemical being used in the pool. This will give a guide as to the hazards of the chemical and precautionary measures which may be needed prior to its use.

Common chemicals

soda ash - (sodium carbonate) is a strong alkaline powder or liquid which is used to quickly raise the pH of a pool. Soda ash should not be added to a pool by shock dosing but should be added slowly and gradually over an extended period. This is a hazardous chemical and should be handled with care.

dry acid - (sodium bisulphate) is a strong acidic powder, which may used to quickly reduce pH. Dry acid should not be added to a pool by shock dosing, but should be added slowly and gradually over an extended period. This is a dangerous chemical and should be handled with care.

hydrochloric acid - (muriatic acid) is a strong acidic liquid which may also be used to reduce pH quickly particularly when the reserve alkalinity is greater than 120 mg/L. This is a dangerous chemical and should be handled with care.

carbon dioxide - (CO_2) is a gas which when added to water forms a weak acid *(carbonic acid)* and may be used to reduce pH when the reserve alkalinity is less than 120 mg/L. It is best used in an automated pH correction system.

sodium bicarbonate - (bicarb) is a weak alkali powder which is used to raise total alkalinity. Shock dosing will not raise the pH to greater than 8.3.

aluminium sulphate - (alum) is a flocculant, a compound used to cause suspended solids in the water to congeal into filterable masses. It is most effective when the pH is between 7.0 and 8.0.

algicides - algae are relatively harmless to humans but they may make the pool unsightly, cause colours, promote bacterial growth, assist in the formation of chloramines and their presence indicates poor pool maintenance. From a safety point of view, algae cause slippery pool walls, pool bottoms and walkways. Algae can be introduced into a pool in the form of airborne spores, blowing free in the air attached to dust or enveloped

by raindrops. They are mainly associated with outdoor pools as they require sunlight to grow.

The most uniformly accepted algal control procedure is to maintain a free chlorine residual of between 1 to 2 mg/L or where pools are warmer than 26^{O}C, a minimum concentration of 3 mg/L.
A successful technique for algal control is to frequently superchlorinate the swimming pool to 10 mg/L particularly after windy conditions and rainfall. The use of a pool cover to prevent contamination and reduce light intensity may also be helpful. There are a range of algicides available on the market and their compatibility with the disinfectant system should be determined at the point of sale. Algicides are an adjunct to pool conditioning for winter. Rough, pitted and poorly finished surfaces within pools are ideal for algal growth and make the control and removal of algae extremely difficult. Smooth, impervious surfaces are required to minimise algal problems.

Storage of chemicals

All pool chemicals should be handled with caution. Pool operators should consult with the relevant authority for precise requirements. Advice on the correct method of disposal for pool chemicals should be sought from the Environmental Protection Agency.

Chemicals should be stored separately in original containers which should be well labelled. Chemicals should not be mixed eg. chlorine based chemicals should never be mixed with acids as the dangerous chlorine gas may be liberated. Extreme care should be taken when handling chlorine gas. Oxidising agents such as pool disinfectants should not be in contact or stored with organic matter as spontaneous combustion may occur. Fires may only be extinguished with copious quantities of water.

The following twelve rules should be observed.

1. Ensure all chemical containers are labelled and follow all instructions implicitly.
2. Store chemicals separately from each other.
3. Store chemicals in a cool, clean, dry, well ventilated, secure area. Store above ground level to minimise spills, and do not store liquid chemicals above dry chemicals.
4. Wear appropriate protective impervious gloves and goggles when handling chemicals.
5. Wash hands before and after handling chemicals.
6. Avoid contact with chemicals on skin and eyes, and avoid breathing vapours.
7. Use a separate scoop for dispensing each chemical.
8. Always add the chemical to water and never add water directly to a chemical.
9. Avoid spillages and clean up any spillage immediately.
10. Remove chemical contaminated clothing immediately.
11. When not in use keep chemical containers sealed with original closure.
12. Empty containers should be washed before disposal.

In case of any poisoning contact the Poisons Information Centre on 131126

Appendix 3

Automatic chemical monitoring and addition equipment

The installation of automatic chemical monitoring and dosing systems for disinfectant and pH control is strongly recommended. This equipment is now installed in most larger pools and is considered superior to manual systems.

Although not fail-safe, automatic systems are usually subject to less operator error than manually controlled systems. The equipment requires calibration at weekly intervals to achieve maximum effect.

Automatic dosing equipment will not operate correctly in unbalanced water. However, an operator with unbalanced water can still maintain reasonable disinfection rates with manual equipment.

Maintenance of balanced water is a highly desirable state. Water that is not corrosive or scaling is an advantage in maintaining the effectiveness of existing plant and equipment. There are two methods of automatic control and dosing of disinfectant. They are by the use of amperometric probes measuring disinfectant residuals or by the use of high resolution oxidation-reduction potential detection probes (ORP or redox). Automatic control may also be exerted over pH.

The amperometric method is designed to measure free available chlorine. The amperometric method may be also used to measure other disinfectants. The results obtained may be used to automatically adjust feed rates of dosing mechanisms providing a greater degree of control over disinfectant usage and compliance.

Much less is understood by pool operators about the principle of redox measurement, which measures the total disinfecting power of all oxidising disinfectant forms in the pool water once set to the correct initial oxidation potential. The signal from the redox probe may be used to automatically dose the pool water. The required redox potential for disinfection will vary slightly between disinfecting systems and is also dependent on the basic water supply potential, which should be assessed and taken into account when the control system is initialised. Redox potentials from 700mV to 750mV are appropriate and are reflected in the chemical criteria.

Operational maintenance

Automatic dosing equipment - maintenance and calibration of the sensors used in automatic dosing systems is necessary for the efficient and effective operation of the equipment. If ozone is used regular cleaning and maintenance of the tubes and regular replacement of the charcoal filter is necessary.

Cleaning filters

The filter should be backwashed when indicated by the loss of head gauges (if fitted) or a reduction in the rate of flow (with a clean strainer basket in place) if a rate of flow gauge is fitted. In the absence of loss of head and rate of flow gauges, the filter should be assessed by the experienced operator. In some situations it may be preferable to set a strict backwash timetable every seven or 10 days, or whatever is considered necessary. As a minimum, filters should be backwashed at weekly intervals during periods of medium to high loadings. Fortnightly backwashing is acceptable in periods of extremely light bather loadings. Domestic pools may be backwashed less frequently depending upon bathing load.

Duration - it is difficult to set a filter backwash duration period. This will depend on numerous variables at each pool including flow rate, filter size, filter design, filter condition, amount of contamination etc.

As a guide, and if the backwash water outlet line is provided with a sample tap, backwash until the effluent is only slightly cloudy.

Any “in line” filters or strainers fitted to the plant should be cleaned at a frequency recommended by the plant manufacturer. A minimum of weekly cleaning is recommended.

The main hair and line strainer fitted to protect the main pump should be cleaned regularly. Differential pressure gauge readings or a reduction in the pool flow rate could indicate this. Pool design, loading and amount of contamination will dictate frequency. The experienced operator should judge this frequency.

Suction cleaning

It is difficult to set a standard for the frequency of suction cleaning of a pool. If visible contamination is present, the pool should be suction cleaned. Large objects (band aids, rubber bands, hair clips, grass and leaves) should be removed immediately with a leaf scoop.

Abnormal conditions in outdoor pools can necessitate suction cleaning on a much more frequent schedule. Wind driven dust can enter a pool and necessitate daily cleaning under some circumstances.

It is established industry standard to suction clean a public pool on two to three occasions per week in times of normal loadings. In periods of light loadings, once per week is considered satisfactory.

Pool Outlets

Scum gutters, wet deck outlets and skimmer boxes all require weekly inspection. Screens should be cleaned on a daily basis. Outlets in painted scum gutters should be checked for reduced openings due to accumulating paint layers. Any reduction in the ability of the scum gutter, wet deck outlets or skimmer box to return water to the filtration plant will result in increased turnover times.

Chemical stocks

Supplies should be checked on a regular basis (weekly is recommended) and re-ordered in advance to prevent any shortage occurring in supply. Stocks should be stored in accordance with manufacturers recommendations of the Workplace Health and Safety Act. Stock rotation should be practised, pool chemicals have shelf life. All chemicals should be used in strict accordance with manufacturers' recommendations.

Appropriate Personal Protective Equipment (PPP) for the chemicals used should be readily available and used. Material Safety Data Sheets (MSDS*)* should be on file for all chemicals stored and used. These must be readily available to all operational staff. The MSDS should be regularly updated.

Daily activities

Daily cleaning is strongly recommended for scum lines around the water line. Due to the pathogens, which may survive in scum lines, regular cleaning is most necessary. In addition an obvious scum line at water level may detract from the appearance of the cleanest and best-maintained pool, and is unlikely to meet with current customer service expectations of patrons. Older style pools lacking scum gutters, or skimmer boxes or wet deck outlets are very labour intensive in this regard, but more regular cleaning will minimise the problem.

Appendix 4

Testing

Frequency of testing (chemical)

Testing of pool water for Free Chlorine, Total Chlorine, other forms of disinfectant and pH should be carried out in line with the recommended times listed below. The times may vary depending on bather load and climatic conditions. Relevant levels should be maintained as recommended in this guideline.

Minimum requirement in high usage swimming and spa pools is:

(a) a test prior to opening in the morning
(b) a test mid morning (nominally 10.00am)
(c) a test at midday (hottest part of the day)
(d) a test mid afternoon (nominally 2.00pm)
(e) a test during the evening (nominally 6.00pm).

Minimum requirement in medium usage swimming and spa pools is:

(a) a test prior to opening in the morning
(b) a test at midday (hottest part of the day)
(c) a test during the evening (nominally 6.00pm).

Minimum requirement in low usage swimming and spa pools is:

(a) a test prior to opening in the morning
(b) a test late afternoon or at closing time.

All results should be recorded in the pool log book and be available for perusal as required. See Records - Appendix 5 for more detail on recommended tests and a sample pool log.

Frequency of testing (microbiological)

It is recommended a monthly microbiological sample be taken from high usage pools, three monthly for medium usage pools and six monthly for all other pools. Samples should be analysed by a NATA or equivalent registered analyst by arrangement. If problems arise with chemical levels, advice of a pool professional should be sought and further microbiological sampling may be recommended. Immediate resampling for microbiological analysis should be performed when unsatisfactory results are obtained. The sample should be at least 250 mls or as stipulated by the analysing authority. (Note: microbiological samples must be collected in sterile containers containing sodium thiosulphate).

The results of a single sample do not give an indication of overall pool management. Ideally, the bacterial results obtained should be entered into a database together with the complimentary chemical analysis so that data is obtained on the pool management performance. This should be considered for all swimming and spa pools. These results should also be compared to bathing loads at the time of sampling to reflect the impact of this important pool operating parameter.

Sampling location

Water samples for all tests, except ozone, should be collected immediately prior to carrying out the test. Water should be sampled from a depth of at least 300mm using an inverted container (plastic or glass) in a location representing a point furtherest from inlets.

Samples for confirming automatic control dosing should be taken from a sample tap strategically located on the return line, as close as possible to the probes in accordance with the manufacturers instructions. As the difference between manual pool readings and automatic control measurements will vary, it is the consistency of variation that is paramount. Diverging or converging readings should be investigated.

Microbiological samples should be collected prior to complimentary chemical parameter sampling. The chemical test results should be noted on the submission form for the microbiological samples.

Testing apparatus

Suitable testing apparatus should be used to ensure accurate results. All glassware and plasticware should be thoroughly washed and rinsed after each testing session. The test methodology specified by the manufacturer of the test kit should be strictly followed. Reagents don't stay viable indefinitely and should be stored correctly and periodically replaced to ensure their effectiveness. To maintain the integrity of the test reagents, they should be stored in a cool, dry place out of direct sunlight. Fresh reagents should be sealed in foil. Liquid testing reagents should be stored in sealed containers. Test kits using orthotolidine as a reagent to determine chlorine or bromine have been withdrawn from sale because of the carcinogenic properties of the reagent. Water after testing must not be discarded into the pool. Expired or defective reagents should be disposed of in the correct manner. The local office of The Environmental Protection Agency should be consulted in this matter.

Plastic or perspex kits known as "4 in 1" or "5 in 1" kits are not suitable for testing public swimming and spa pools. The following test methods are some of those able to be used.

a) Chlorine/bromine

- A calorimetric comparison method based on DPD reagents using standards capable of measuring to 0.2 mg/L units within the recommended disinfectant range.
- A photometric method based on DPD reagents capable of measuring to 0.2 mg/L units within the recommended disinfectant range.

b) pH

- A photometric method capable of measuring to 0.1 pH units.
- A pH meter.
- A colorimetric method capable of measuring to 0.2 pH units.

c) Total alkalinity

- Titration method using an appropriate indicator (and sodium thiosulphate where elevated chlorine concentrations are detected).

d) Isocyanuric acid

- Any test kit available.

e) Clarity

- There is no test specified at this time for water clarity. Water clarity should be maintained so that sharply defined lane markings or other features on the pool bottom at its greatest depth are clearly visible from the side of the pool.

f) Total dissolved solids

- Electronic equipment may be used to measure the conductivity of the pool water sample. The instrument is calibrated with a standardised solution. The actual concentration of total dissolved solids is read directly from the meter. It should not exceed 1500 ppm.

Appendix 5

Records

A register or log should be used to record the results of every test performed at a swimming or spa pool. There is a wide variety of test register sheet designs, which vary according to the type of pool and disinfectants used. There is no ideal test register sheet. Each pool manager or local government should design their own test register sheet according to local needs. The register or log is to be available for perusal by appropriate persons upon request.

A daily register sheet is essential and should include the testing time of each pool and columns for entries such as:

- date and time.
- disinfectant concentrations (and oxidation reduction potential).
- pH.
- temperature (when heated).
- water clarity.

Other entries that may be made include:

- backwashing.
- total dissolved solids.
- chlorine bottle usage.
- cyanuric acid concentration.
- total alkalinity.
- water meter reading.
- chemical adjustments made.
- admission data.
- dose settings.
- all maintenance required or scheduled.
- chemical stocks on hand.
- weather.
- bathing loads.
- sample results (microbiological and chemical).
- water balancing.
- general remarks including significant events.

One person should be made solely responsible for pool testing and recording of results each working shift and the register sheet should include their name.

Date	Disinfectant Level					pH	Temp	Clarity	Stabiliser	Adjustments	Bact Results	Admissions	Maintainence	General
	Time of test													
	6	10	12	2	6									
___/___/__														
___/___/__														
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Appendix 6

Operator qualifications

A pool operator is the person nominated to be in charge of the pool. This should be someone dedicated on site specifically to control the pool, spa or recreational centre operations. Operators of public swimming pools and spa pools should have a sound and demonstrable knowledge of pool operating procedures. At present there are no legislative requirements for qualifications of swimming pool operators. While some written information can be obtained, training is considered to be more appropriate.

Pool operators should have a sound knowledge of:

- pool plant
- pool maintenance
- water chemistry
- pool disinfection requirements
- water testing
- first aid
- life saving and resuscitation techniques

For further information regarding swimming pool safety, please consult "Safety in Swimming Pools, Guidelines for Safe Pool Operation" The Royal Life Saving Society, Qld Branch.

At the time of writing, available courses included

1. Plant Operation - Swimming Pool Course CNO455 - Open Learning Institute of TAFE

2. Swimming Pool Plant Operators Course CNREC 012 - Southbank Institute of TAFE.

Appendix 7

Pool and spa management

Patron behaviour signage

The following signage is recommended for display for pool patrons:

- If you currently have, or have had diarrhoea in the last 14 days, you should not enter the swimming pool.
- Please use the toilet and shower using soap before entering the pool.
- Avoid swallowing/drinking the pool water.
- Wash hands thoroughly after using the toilet or changing nappies. Please use the soap provided.
- Do not allow babies, toddlers or incontinent persons to enter the water with soiled nappies or naked. Use of waterproof pants might be considered.
- Do not change nappies beside the pool or rinse off an undiapered child in the pool. Use the change room provided.
- Accidents can happen. If you or your children don't quite make it to the toilet, please tell reception immediately. Confidentiality will be respected.

Faecal accident/incident policy

All pools should have a faecal accident/incident policy in place. This policy should be sub-divided into the following reaction categories.

1. Loose runny stool

- Clear the immediate area of the pool of patrons.
- Add a coagulant to the pool area.
- Remove obvious contamination/waste by use of the pool suction cleaner. Waste should be discarded directly into a sanitary sewer, or a container for later disposal to a sanitary sewer. Clean the suction device and dispose of washings to a sanitary sewer.
- Shock dose the pool with chlorine dioxide or chlorine overnight.

2. Solid stool

- Clear the immediate area of the pool of patrons.
- Remove the stool using a fine mesh scoop.
- Add a disinfectant to the vicinity (one litre of sodium hypochlorite or one cup of calcium hypochlorite).

3. Employee education

- Educate all staff with relevant information on *Cryptosporidium* and *Giardia* (refer Appendix 1 and 2 in the *Code of Practice for the Control of Cryptosporidium, and Giardia in Swimming Pools, Leisure Pools, Spas and Hydrotherapy Pools)*.
- Ensure all staff are capable of communicating this information in an informed and sensitive manner to patrons when required.
- Ensure all staff are aware of the faecal accident/incident policy.

Appendix 8

Water balancing

Pool professionals place great importance on water balancing and this view is supported but is not a requirement of these guidelines.

The term “chemical water balance” means the swimming pool water is in a state of equilibrium with calcium compounds. Balanced water prolongs the life of a pool and its fittings, assists with preventing stains and improves bather comfort. If pool water does not have enough dissolved salts, it will try to obtain them by etching or eroding the pool surfaces and fittings. If the pool water has too much dissolved salts, it will try to get rid of the excess in the form of salt precipitates or deposits known as scaling.

The three major factors that operate interdependently affecting water balance are pH, total alkalinity and calcium hardness. As pH rises, salt solubility decreases and therefore, in hard waters with a high alkalinity, scaling may occur. As total alkalinity rises, again the solubility of salts tends to decrease and again in hard water with a high pH, scaling may occur. Calcium hardness is a measure of all the different dissolved calcium compounds found in the pool. If calcium hardness is low or too high it does not cause problems in a pool unless the water is not chemically balanced. Temperature affects the solubility of salts in a pool. Generally, a salt is less soluble in water at higher temperatures (boilers and heat exchangers) than at lower temperatures.

Determination of chemical water balance

The Calcium Saturation Index can be used to determine chemical water balance from pH, total alkalinity and calcium hardness. In order to simplify the Index, the “Water Balance Chart” for temperatures of either 30^0C or 40^0C, has been devised and is attached. Other more versatile charts are available for purchase from some chemical suppliers and pool shops.

The water balance chart is divided into two scales where scale A is for water at 30^0C and scale B is for water at 40^0C. The total alkalinity scale is common to both scale A and scale B. For swimming pools scale A should be used and for spa pools use scale B.

Test the pool water for pH, total alkalinity and calcium hardness and then:

1. plot calcium hardness on its scale first because it is the most difficult parameter to alter

2. plot total alkalinity because it is also a stable parameter

3. draw a line between the plots for calcium hardness and total alkalinity

4. note the pH from the chart

5. compare the chart pH to the measured pool pH.
   a) If the pool pH is within 0.2 of the chart pH, then the pool is balanced.
   b) If the pool pH is greater than the chart pH by more than 0.2, then the pool has a positive imbalance and could cause scaling.
   c) If the pool pH is less than the chart pH by more than 0.2, then the pool has a
   negative imbalance and is termed corrosive.

Example

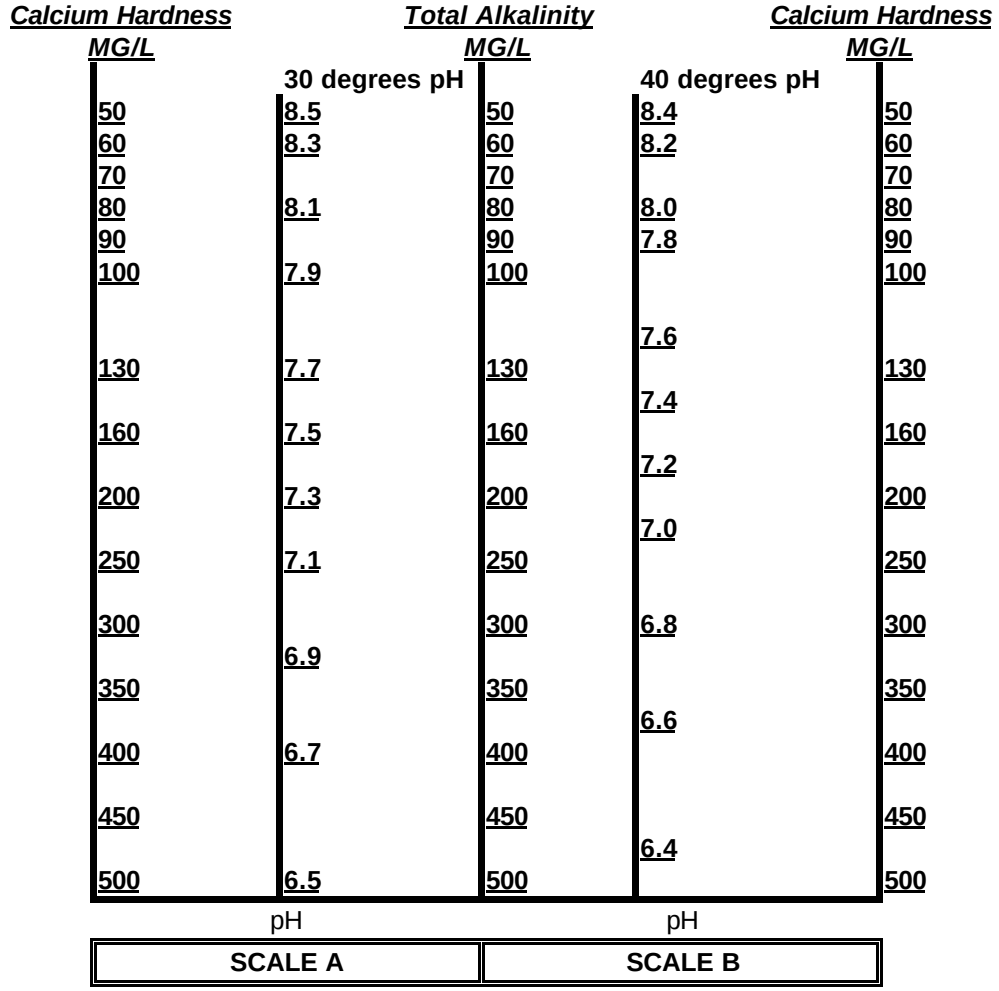
Consider a pool operated at 26^0C and testing determines the results of:

total alkalinity	: 160 mg/L
pH	: 8.0
calcium hardness	: 100 mg/L

Solution

Use scale A because the water temperature approximates 30^0C. Plot both total alkalinity and calcium hardness, draw a line between the two plots and determine that the chart pH to achieve balanced water is 7.7. The actual pool pH 8.0 is higher than the chart pH by more than 0.2. Therefore in this case the pool is likely to be causing scaling and feel 'hard' to bathers.

WATER BALANCE CHART



Appendix 9

Amenities

Showers

To encourage pre-showering, an adequate number of showers should be located in the dressing room in a position by which patrons have to pass them before entering the pool area. Signs should be erected to encourage showering before swimming. The shower environment can be humid, wet and allow the proliferation of bacterium and fungi. Thorough and regular cleaning is needed to prevent this and to remove soap accumulations.

Test room/area

A separate area or room away from the chemical storage area should be provided where testing of pool water may be carried out. The test room should be provided with a sink and tap water, and adequate bench space.

First aid

First aid equipment and a sick room should be provided. A First Aid Officer (FAO) should be on duty during pool operating hours. The First Aid Officer should have a first aid certificate from a recognised training institution such as St Johns Ambulance or the Royal Life Saving Society. Signs should be erected to demonstrate resuscitation techniques.

Ventilation

Adequate ventilation for indoor pools is necessary to dilute volatile air contaminants.

Appendix 10

Common pool problems

Problem	Reason	Solution
Chlorine odour and eye irritation	Combined chlorine level too high	Increase free chlorine level to oxidise combined chlorine
Discoloured water	Various metals such as copper entering pool, eg. as corrosion product, being oxidised by chlorine	Increase pH to 7.4
Water has a dark appearance	Products from breakdown of large amounts of organic material (eg. Tannins)	Check filter operation Superchlorinate
Green water and slippery surfaces	Indicates algae growth due to inadequate chlorination	Superchlorinate
Metal fixtures corroding	Water pH too low	Increase pH to 7.4
Scaling on pool surfaces or heater	Calcium hypochlorite (powder) added directly to pool water	Dissolve first in a bucket before adding to pool or change to sodium hypochlorite (liquid)
Cloudy water	Excessive combined chlorine, or free chlorine rapidly dissipated	Superchlorinate
Cloudy water	Poor filtration	Check filter medium and backwash or clean
Cloudy water	Calcium hypochlorite added directly to water	Dissolve prior to adding
Chlorine disinfectant appears to be ineffective	Shelf-life exceeded	Check shelf-life. Note that sodium hypochlorite (liquid) has a maximum shelf-life of eight weeks whereas bromine (as BCDMH) and calcium and lithium hypochlorite (powder) have more than 12 months shelf-life.

Appendix 11

Health risks

In poorly maintained swimming and spa pools, people may be at risk from infections caused by a number of micro-organisms. Some of these may be naturally present on hair or skin or in our ears, mouth, nose, intestinal and uro-genital tract. Inadequately treated pool water or surfaces (such as shower floors) may transmit infections.

Bacterial pathogens

Pseudomonas aeruginosa is the most common disease causing agent associated with waterborne disease outbreaks. It is an opportunistic pathogen and has been identified as causing eye, ear and skin infection. Its normal habitats are water, soil and vegetation but it may also be of human origin. Although relatively resistant to a range of disinfectants, chlorination of normal swimming pools should be sufficient to kill the bacterium. However, where there is water turbulence, elevated temperature and heavy bather-loads such as in spa pools, considerably greater care is needed to ensure their safe operation and the eradication of this organism.

Legionella spp. causes a serious disease of the lung known as Legionnaires disease *(legionellosis)* and a less debilitating disease called Pontiac fever. They are found in the natural environment, such as soil, rivers, lakes and creeks. Outbreaks have mainly been associated with air conditioning cooling systems and potable water systems *(especially hot water)* although spa pools have also been implicated. Legionellosis is caused through inhalation of contaminated aerosols.

Coagulase positive staphylococci are regularly isolated from swimming pools and spa pools as they are normal microflora of the skin, ear and nose. These micro-organisms can cause skin infections such as boils, carbuncles and wound infections. They are fairly resistant to disinfection but have not been shown to be a public health problem in well maintained pools.

Mycobacterium marinum causes chronic skin ulceration known as "swimming pool granuloma" which may last up to three years if untreated.

Shigella, Salmonella and Campylobacter have been implicated as causative agents of gastrointestinal diseases but outbreaks as a result of swimming are uncommon.

Protozoan pathogens

Cryptosporidium is a protozoan parasite of about four to seven microns in diameter. It is very resistant to common disinfectants. *Giardia* is a minute protozoan parasite of about eight to 12 microns in diameter. It is resistant to common disinfectants though

not to the same extent as *Cryptosporidium*. ***Cryptosporidium*** and ***Giardia*** may be excreted by infected humans into swimming pools through faecal accidents and may cause outbreaks of diarrhoea. A carrier state exists where humans may be infected without showing obvious symptoms.
It is more important to prevent the entry of these organisms into the pool and strategies such as requiring all bathers to wear swimming costumes at all times should be considered. For more detail see ***Code of Practice for the Control of Cryptosporidium and Giardia in Swimming Pools, Leisure Pools, Spas and Hydrotherapy Pools.***

Naegleria fowleri is a pathogenic free-living amoeba which has been shown to cause a fatal disease called primary amoebic meningo-encephalitis. The disease is contracted by the invasion of the amoeba through the nose into the brain. In nature, the organism thrives in mineral springs, thermal bores, rivers and lakes. These waters are generally heated above $25^{O}C$, which assists the parasite in its metabolism and survival.

Viral pathogens

Enteroviruses are the major causative agents of swimming pool gastroenteritis. They are most frequently found in wading pools used by infants and young children where bather hygiene is poor and water volume is small.

Adenoviruses types 3 and 4 cause pharyngo-conjunctival fever among bathers. The disease is characterised by sore throat, fever and conjunctivitis and is frequently associated with diarrhoea.

The Herpes simplex virus causes fever and an unwell feeling. It has been reported to be able to survive for long hours in warm, humid conditions and is spread by persons with cold sores.

Plantar warts are caused by a papovavirus, which may be transmitted by contact with contaminated floor surfaces.

Yeast and fungal pathogens

Large numbers of fungi can be found in indoor swimming pools. Athlete's foot or tinea pedis is caused by certain fungal pathogens (dermatophytic fungi), including *Trichophyton rubum, Trichophyton mentagrophytes* and *Epidermophyton floccosum.* These fungi have been isolated from shower stalls, floors and so forth.

The yeast, ***Candida albicans****,* may cause uretho-genital, skin and nail infections in individuals with normal immune defences as well as serious systemic infections in debilitated patients.

Heat illness

In natural sunlight the main forms are heat exhaustion and severe sun burn. The body has no mechanism to warn of overheating. In saunas, dehydration, heat exhaustion and fainting may occur. On entering a heated pool or sauna the skin blood vessels dilate to help lose heat and keep the body cool. The heart has to pump faster and so the heart rate increases. If there is insufficient blood going to the brain, there is a lack of oxygen and a person may feel dizzy and even faint. Deaths have resulted when alcohol has been consumed and the body subjected to heat stress.

Heat exhaustion is caused by a loss of water and electrolytes. Any sustained muscular exertion can cause this. It is relieved by rest and fluid and electrolyte (salt) replacement. Proper conditioning prior to heavy muscular exertion should be attempted. No heated swimming pool or spa pool should be operated at a temperature greater than $38^{O}C$ and exposures at greater than body temperature should not exceed 20 minutes for a healthy adult. Children and those with medical conditions (heart conditions) are particularly at risk and should seek medical advice. A suitable warning sign could read “Children under the age of 6 years and persons with medical conditions should not use the heated spa pool. Seek medical advice."

Chemical conditions

While too little residual chlorine will allow bacteria to grow, too much chlorine, bromine or prolonged swimming, particularly in salt water, can cause conjunctivitis (eye irritation), dermatitis (skin allergy) and dry scaly skin. Some people may suffer skin sensitivity if bromine (in the form of BCDMH) is used.

Shade

The use of an outdoor swimming or spa pool complex by patrons exposes them to harmful ultra violet radiation. Guidance on shade can be obtained from *Shade for Public Pools - Guidelines for shade protection against ultraviolet radiation at outdoor public pools* published by Queensland Health.

Appendix 12

Potential health problems associated with spa pools

Health problems	Causative agent	Predisposing factors to infection
Follicular dermatitis	*Pseudomonas aeruginosa*	High numbers of micro-organisms Long exposure time High temperatures
Skin, ear and eye infections	*Pseudomonas aeruginosa* *Pseudomonas cepacia* *Mycobacterium marinum* Papilloma viruses *Acanthamoeba*	Injury Spa environs and materials Skin lesions from recent trauma Immune deficiency
Skin irritation	Chloramines	Inadequate dumping frequency Low chlorine disinfectant levels
Respiratory infection	*Legionella, Pseudomonas spp., Enterobacteriaceae*, free-living amoebae, adenoviruses	Aerosol dispersion of contaminated water Poor disinfection practice Immersion of the head Pre-existing respiratory disease
Genito-urinary infection	*Pseudomonas spp* *Enterobacteriaceae,* *Trichomonas, Chlamydia,* *Herpes,* yeasts and fungi	Excessive exposure to spa water Careless bather practices
Gastro-intestinal infection	*Giardia, Cryptosporidium,* bacterial enteric pathogens	Faecal pollution of water Ingestion of water.
Heat stress *(hypothermia)*	Excessive exposure	High temperature, especially above 40^0C (or above 38^0C for those at risk such as the elderly or those with heart conditions). Long exposure time Predisposition to heat stress Heart conditions

If temperature is above 40^0C there is potential for increased evaporation, bather discomfort, scaling and increased use of disinfectants.

Glossary

Combined chlorine	chlorine that has combined with ammonium compounds or organic matter containing nitrogen to form chloramines.
ppm	an abbreviation for PARTS PER MILLION. The unit of measurement used in chemical testing which indicates the parts by weight in relation to one million parts by weight of water. It is essentially identical to the term milligrams per litre (mg/l).
Shock dosing	the addition to swimming and spa pool water of several times the daily dose of disinfectant. Usually carried out when excessive algal growth has occurred.
Super chlorination	the addition of two to four times the normal daily dose of chlorine to pool water to eliminate chloramines and other impurities. (Usually done overnight)
Total Alkalinity	the ability or capacity of water to resist change in pH; also known as the buffering capacity of water. Measured with a test kit and expressed as ppm.
Turnover rate	the period of time (usually in hours) required to circulate a volume of water equal to the swimming or spa pool capacity.

For enquires related to the guideline please contact

Communicable Diseases Unit
Queensland Health – Telephone (07) 3234 1155

February 2000.