FREE CHLORINE

A MANUAL FOR SWIMMING POOL PLANT OPERATION AND MAINTENANCE

and Pool Test Records

By Les Mole

A Note From the Author

Managing a public swimming pool brings with it a huge responsibility. This workbook provides an introduction for people to begin to understand the complex nature of this type of business.

Often the skills required to run a safe, healthy aquatic centre are under-estimated.

To become truly efficient at operating a public swimming pool takes many, many hours of perseverance, patience, networking and learning. It is more like a trip of discovery, than a job.

Interested persons will be taking their first steps by immersing themselves in this manual. Always remember, there are no so-called gurus in this industry. Swimming pool management is the epitome of "Life Long Learning". It is all about solving problems. Some of the problems can be readily corrected, however others that should be resolved by the obvious, often require many hours of trial and error.

This manual will equip the reader with a tool box of ideas and experience that should at least give direction to effective aquatic facility management.

I strongly recommend that any person who is serious about operating a public facility, should attend a recognised training program in pool plant operation and management.

Good luck.

Les Mole

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Introduction

This manual and workbook is designed specifically for operators of public swimming pools.

Aquatic activities account for approximately 50% of all sport and recreation enjoyed around Australia. At the 2000 Sydney Olympics we witnessed the 100th Gold Medal for Australia. Approximately half of those gold medals came from aquatic sports.

Positioning a swimming pool for clear 'line of sight' vision is important.

Being able to survive in water is critical for populations worldwide, as it is one of the biggest accidental killers, of children under the age of five years.

We have all been touched by stories of children drowning in eskies, bathtubs and back-yard swimming pools, lakes, rivers, dams and at the beach.

Who are the forgotten heroes that help us through this most critical age of our lives? Some may herald the local learn to swim teacher, and whilst they provide a face, the most significant "expert" is certainly the person responsible for providing public swimming, that is both safe and hygienic.

This collection of experience is intended to help to educate those people who work around the clock, to provide us with an environment, within which we live and grow. The information in this book is provided as an advisory resource. It is not intended to override any legislation, which may exist and/or be enacted, to regulate the operations of a public swimming pool. Pool operators should be aware that they may be liable for heavy penalties if they do not provide their customers with both a safe and healthy aquatic environment.

Pool Plant Operation and Maintenance is a highly eclectic field of employment, and this manual brings together some of those heuristic skills, required to operate a facility.

A typical 50 metre Olympic Pool.

The Wet Collection

There should be no illusion, running a public swimming pool is possibly one of the most testing and exhausting careers, for an individual to undertake.

A mass of water, that is exposed to the atmosphere and all its' elements around the clock, and used exhaustively by those who come to enjoy it, must result in high maintenance. Public swimming pools by their very nature, require the competency of a person, who has an adaptation to basic rules of both mathematics and science, and who is able to work long hours and remain calm and courteous at all times.

Whilst no two pools are alike, the design of a facility is paramount. Making mistakes during the design phase is inexcusable, particularly with the expertise that currently exists around the world.

Knowing the types of users is the first consideration for designing an aquatic facility. Egos and ambitions should not be permitted to interfere with what will become "someone else's" problem to manage.
It should be recognised, that having the biggest swimming pool is not necessarily the best ingredient to designing a functional and cost effective facility. Reducing the depth of the pool tank and providing sloping beach entry gradients can help to reduce the volume of water, which ultimately needs to be filtered and disinfected.

Carefully consider that lap-swimmers place high demands on pool space, and although they are frequent users of a facility, individually their numbers may not contribute significantly to the running costs. Both program and recreational users are by far the biggest target markets for the successful facility manager, and their needs should be identified, and embedded in the overall concept.

Fully functional dive pool.

The swimming pool industry is essentially a service industry and all of the idiosyncrasies associated with servicing a more educated and demanding consumer, have to be considered.

The pool is built for extensive use and as many humans as possible, will want to come and enjoy it. The facility manager must be mindful however, that humans leave a consistent trail of excrement with every move. Whether it's outside the pool on the concourse, in the car park or in the change rooms, or enjoying the aquatic experience to ranging depths, humans discard waste just like a lost mouse does as it ventures around the furniture in a building. Wherever the public travels, a cleaner must follow.

One of the great dangers of an entertainment centre like a public pool, is that its most favourite areas are under constant public scrutiny for cleanliness. Staff have to expect that their role includes the skills of a cleaner, super salesperson and public relations expert. The service industry caters for both domestic and international demands, which will require staff, who are often in constant public view.

It is important for all staff to be courteous and friendly.

Staff

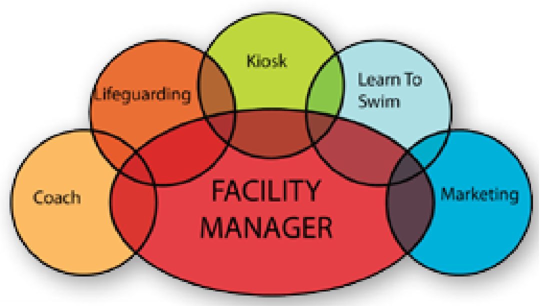
The staff employed at any facility are it's greatest asset. In the overall scheme of things, very few staff are employed on a full time basis. However the industry is ideally suited to younger energetic people who are enrolled at university and require seasonal and casual employment to maintain a comfortable lifestyle.

Although some pools are large enough to support a staff structure and chain of command, in many cases the facility is managed 'shamrock style', where the facility manager is central to a multitude of experts and professionals, and most employees have a multi-dimensional role.

When taking on the role of facility manager, it is important to realise that the position is responsible for a business that usually serves its customers seven days per week, and could be open to the public in excess of eighty five (85) hours per week.

Many short courses are available for training staff. These include programs offered by organisations like the Royal Life Saving Society - Australia, but are certainly not limited to the Bronze Medallion, Pool Lifeguard, First Aid and Resuscitation or Pool Plant Operation and Maintenance.

Specialist training courses may include defibrillation and oxygen resuscitation. Short courses are best suited as they are provided at minimal cost, can be provided either on-the-job or off-the-job, and they do not take up excessive work time if they are provided at the expense of the employer.



Staff have many work functions. The skills overlay the jobs that need to be done and the structure usually is framed shamrock style.

Peak bodies like AUSTSWIM also provide training in learn to swim and swim coaching.

In recent times, the training agenda has shifted towards the implementation of competencies from national training packages. The aim of this strategy is to provide the participant with training that is recognised nationally and the adaptation of skills and qualifications, that will lead to higher qualifications.

Patrons impact on design

One key ingredient for operating a successful public swimming pool is understanding and coping with the variety of demands by the users. The modern day customer, living in a sophisticated society, has grown to expect more for less.

Unfortunately for pool operators, providing healthy, sparkling water looks very simple. Many customers often visit a facility with the notion that they are not swimmers, and question, “why they should pay”, an entry fee.

Operating aquatic facilities comes with a huge financial risk. If it was just those swimming who paid for entry, the admission cost would sky-rocket, or alternatively, someone else would have to subsidise the pool’s operational costs, eg. a level of government.

Swimming pools should promote a healthy lifestyle.

Young children enjoy aquatic facilities but place additional demands on facility management.

Many modern 50 metre swimming pools cannot operate without significant financial support from at least one level of government, or some other reliable financial source. Patrons are rarely aware of the comprehensive list of expenses which operators face, on a daily basis.

To complicate matters further, the viability of the local aquatic facility relies heavily on favourable weather conditions, to attract the bathing public.

Different pool users present a range of associated problems for the facility manager eg. younger children may be more prone to having toiletry accidents, compared to older aged children.

All patrons however will have some impact on the overall operations of a facility.

What governs public swimming pool management?

Most public swimming pools across Australia are owned by either Local Government Authorities or State Governments. The age of pools vary, with many being constructed around the time of the 1956 Melbourne Olympics, and before and after the Sydney 2000 Olympics. This is one of the great legacies of hosting the Olympic Games, and it motivates everyone in the community to invest in sports facilities, for future generations.

The larger heated facilities with a capacity of 5 or 6 megalitres of water, certainly require government financial backing to make them financially viable.

For sometime, there was a culture of leasing facilities to private individuals but soaring operational costs have lessened the viability of the pool as a business, and many centres have shifted back under the auspices of government management and control.

Because of the three tiered government structure in Australia, there is no single law enacted for the management of public pools. Just some of the standards, codes of practice and practice notes that do apply however may include:

- HB 241 – 2002 Standards Australia -Water Management for Public Swimming Pools and Spas 2nd Edition.
- Guidelines for Safe Pool Operation – Royal Life Saving Society Australia.
- Practice Note 15 – Water Safety, NSW Local Government Department.

However this is by no means an exhaustive list, and a more comprehensive list of Australian Standards can be seen at www.saiglobal.com.au.

The Royal Life Saving Society - Australia Guidelines for Safe Pool Operation

Government Departments have also produced some very effective resources and these include journals from Health Departments on the control of Cryptosporidium and Giardia, and State specific guidelines on pool water quality, testing and management.

The facility manager/management team must assume the responsibility for developing a site- specific Operations Manual.

Developed as a loose leaf document, the contents will need to be constantly reviewed.

Time and resources dedicated to the Operations Manual, will make it a valuable tool for training and retraining staff.

The AS3000 Series is of particular importance for pool management, as it is an Australian Standard that sets out the minimum requirements for the design, construction and testing of electrical installations.

The requirements of AS3000 are intended to protect persons, livestock and property from electric shock, fire and physical injury hazards, that may arise from an electrical installation that is used with reasonable care, and with due regard to the intended purpose of the electrical installation.

Only licensed electricians should be permitted to work on swimming pool plant and equipment.

Electrical equipment in a plant room must be maintained by a licensed electrician.

Work Place Health and Safety.

The Workplace Health and Safety Act 1995, sets out the workplace health and safety laws for Queensland. There are similar acts in all States and Territories, around Australia.

The Act aims to prevent a person's death, injury or illness being caused by a workplace or workplace activities, by eliminating or minimising exposure to risk. Improving workplace health and safety will significantly reduce the human and financial cost of workplace injury and disease. Workers, their families, employers, industry and community, benefit from improved workplace health and safety. Knowing about the law and how it is enforced can assist you to improve workplace health and safety in your workplace. The Act provides for a modern regulatory regime that takes into account:

- ❖ Changing labour market
- ❖ Compliance and enforcement mechanisms

The Act assigns a legal responsibility to those who can best control the risk in the workplace.

Certain obligations are placed on persons associated with workplaces, including;

- Employer
- Self-employed persons
- Workers
- Contractors
- Persons in control of workplaces
- Designers, manufacturers, importers, and suppliers of plant
- Erectors and installers of certain plant
- Manufactures, importers and suppliers of substances and
- Owners of specified high risk plant

In the absence of specific advisory standards, industry codes of practice, regulations and guides relevant to your workplace, the risk management process can assist you to meet your health and safety obligations.

The five steps of the risk management process are:

1. Identifying hazards (eg. electricity, unguarded machinery, chemicals, noise, etc.);
2. Assessing risks that may result because of the hazards;
3. Deciding on control measures to prevent, or minimise the level of the risks;
4. Implementing control measures; and
5. Monitoring and reviewing the effectiveness of the control measures that are implemented.

Where more than 30 workers are employed in the workplace, a Workplace Health and Safety Officer must be appointed.

The Workplace Health and Safety Act 1995 is enforced by inspectors from the Division of Workplace Health and Safety. Primarily, the role of an inspector involves monitoring and ensuring compliance with workplace health and safety legislation.

Some of the key features of the Workplace Health and Safety Act are:

- ❖ Employer obligations
- ❖ Employee obligations
- ❖ Penalties
- ❖ Persons in control
- ❖ Enforceable undertakings
- ❖ Powers of Inspectorate

An open balance tank poses enormous risk to the staff of an aquatic centre and the patrons.

Who is an employer?

A person is an employer if;

- The person conducts a business or an undertaking for gain or reward, and
- In the conduct of the business or undertaking, the person engages someone else to work, other than under a contract of services, for the direction of the person, or
- A person engages someone else to do whether the person engaged works for gain or reward or on a voluntary basis.

An employee also has certain obligations under the Act;

- To comply with the instructions given for workplace health and safety at the workplace by the employer at the workplace.
- A worker must use personal protective equipment if the equipment is provided by the worker's employer and the worker is properly instructed to use it.
- Not to wilfully or recklessly interfere with or misuse anything provided for workplace health and safety at the workplace.
- Not to wilfully place at risk the workplace health and safety of any person at the workplace.
- Not to wilfully injure himself herself.

A self-employed person is described as a person 'who conducts business or undertaking for gain or reward; and in the conduct of the business or undertaking, the person is not an employee or worker'. Employers should note however, that they have an obligation to ensure:

1. The workplace health and safety of each of the employer's workers in the conduct of the employer's business or undertaking,
2. The employer's own workplace health and safety in the conduct of the employer's business or undertaking,
3. Other persons are not exposed to risks to their health and safety arising out of the conduct of the employer's business.

Although there are alternatives to prosecution like providing remedies for poor behaviour, implementing actions or programs to prevent future breaches and education programs to promote and improve safety performance, severe penalties can apply. (Refer Table1 on page 9)

Penalties under the WHS Act

Offence	Individual	Imprisonment	Corporation
Multiple deaths	$150,000.00	3 years	$750,000.00
Offences causing death or Grievous Bodily Harm (GBH)	$75,000.00	2 years	$375,000.00
Exposure to a substance likely to cause death or GBH	$56,250.00	1 year	$281,250.00
Offences causing bodily harm	$56,250.00	1 year	$281,250.00
Other Offences	$37,5000.00	6 months	$187,500.00

Confined spaces can only be accessed by qualified personel.

The aquatic facility manager should be aware of a range of other legislative requirements of a generic nature that are described under utilities like:

- Dangerous Goods Safety Management Act 2000
- Electrical Safety Act 2000

Case Study #1 X Company - Breaches section 28(1) re provision of safety equipment at the workplace. - Worker sustained head injuries. - No specific procedures were in place for inspecting machinery nor were technicians required to isolate machinery in the saw cabinet before they made an inspection. Fine = $40,000.00
Case Study #2 Y Company - Double fatality - Breaches of WHS Act - Coroner's inquest found that the deaths could have been prevented had procedures outlined in the Australian Standard for working in voids been followed. Fine = $125,000.00
Case Study #3 Z Company - Breaches of s24 and s28 - Normal practice to clean up the workplace before the end of the shift but there was no written procedures. - Worker had not received safety training. Fine = $18,750.00

Case studies of WHS fines for ignoring WHS responsibilities under the act

All open drains should be covered.

The Swimming Pool

Although swimming pools (and their associated plant and equipment) first appear to be complex and complicated to operate, they are realistic man-made structures, which in many cases can be self-automated and effectively managed given the correct technical 'know-how'. For the past few decades there have been constant attempts by designers, architects and manufacturers to develop new products and resources for this lucrative part of the leisure market.

The basic design of a swimming pool can be simply described as a reservoir of water, which is linked to a plant room, by a series of pipes and fittings. The water leaves the main reservoir by over-flow drains or skimmer boxes and is drawn by a pump, which forces the water through a filter. After completing the filter process, disinfectant is added, and the water returns to the pool. Other associated plant can be part of this process at any stage eg. a water heater.

A well maintained swimming pool can provide a number of health benefits to the community.

The key components of a swimming pool include:

- The pool basin
- Overflow drains or skimmer boxes
- Lint baskets
- Pumps and pipes
- Filters
- Balance tank
- Chemical dosing unit
- Heater
- Back wash
- Plant rooms
- Chemical storage
- Cleaning equipment
- Safety equipment
- Rescue equipment
- Personal protective equipment
- Shade and seating
- Emergency access
- Water and electrical supplies
- First aid room
- Administration centre
- Toilets and change rooms

The effective and efficient flow of water around the system is essential and the system should be 'water tight' at all times. There should never be any leaks, and the plant room should be dry and sterile, just like a first aid room.

The plant room should never be used as a spare storage area, and only chemicals associated with the pool water quality management should be stored in the plant room, in allocated 'bunded' areas.

A water recycling plant.

A bund is built around the base of all chemical storage containers. It should have the capacity to hold 110% of the volume of the chemical being stored and will act as a reservoir should the chemicals' container rupture.

Australian standards apply to the safe storage and handling of chemicals. Each chemical should be identified by a Material Safety Data Sheet (MSDS), which should then be posted adjacent to where the chemical is being stored, and in the main administration area.

A large plant room with inlet pipes leading to lint baskets and water is then pumped under pressure to the filters.

Humans are one of the main causes of polluting swimming pool water.

Water

Water is a common chemical substance that is essential for the survival of all known forms of life. In typical usage, water refers only to its liquid form or state, but the substance also has a solid state, ice, and a gaseous state, water vapor or steam. Water covers 71% of the earth's surface. Water moves continually through a cycle of evaporation or transpiration (evapotranspiration), precipitation, and runoff, usually reaching the sea.

Clean, fresh drinking water is essential to human, and other life. Access to safe drinking water has improved steadily and substantially over the last decades in almost every part of the world. Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. Approximately 70 percent of freshwater is consumed by agriculture.

Humans use water for many recreational purposes, as well as for exercising and for sports. Some of these include swimming, waterskiing, boating, and diving. In addition, some sports, like ice hockey and ice skating, are played on frozen water. Lakesides, beaches and waterparks are popular places for people to go to relax. Many find the sound of flowing water to be calming, too. Some keep fish and other life in aquariums or ponds for show, fun, and companionship. A 2006 United Nations report stated that "there is enough water for everyone", but that access to it is hampered by mismanagement and corruption.

Water is a chemical substance with the chemical formula H2O: one molecule of water has two hydrogen atoms covalently bonded to a single oxygen atom.

The major chemical and physical properties of water are:

Water is a tasteless, odorless liquid at standard temperature and pressure. The color of water and ice is, intrinsically, a very light blue hue, although water appears colorless in small quantities. Ice also appears colorless, and water vapor is essentially invisible as a gas.

Water is transparent, and thus aquatic plants can live within the water because sunlight can reach them. Only strong UV light is slightly absorbed.

Since oxygen has a higher electronegativity than hydrogen, water is a polar molecule. The oxygen has a slight negative charge while the hydrogens have a slight positive charge giving the article a strong effective dipole moment. The interactions between the different dipoles of each molecule cause a net attraction force associated with water's high amount of surface tension.

Another very important force that causes the water molecules to stick to one another is the hydrogen bond.

The boiling point of water (and all other liquids) is directly related to the barometric pressure. For example, on the top of Mt. Everest, water boils at about 68 °C (154 °F), compared to 100 °C (212 °F) at sea level. Conversely, water deep in the ocean near geothermal vents can reach temperatures of hundreds of degrees and remain liquid.

Water has a high surface tension caused by the weak interactions, (Van Der Waals Force) between water molecules because it is polar. The apparent elasticity caused by surface tension drives the capillary waves.

Water also has high adhesion properties because of its polar nature.

Water is a very strong solvent, referred to as the universal solvent, dissolving many types of substances. Substances that will mix well and dissolve in water, e.g. salts, sugars, acids, alkalis, and some gases: especially oxygen, carbon dioxide (carbonation), are known as “hydrophilic” (water-loving) substances, while those that do not mix well with water (e.g. fats and oils), are known as “hydrophobic” (water-fearing) substances.

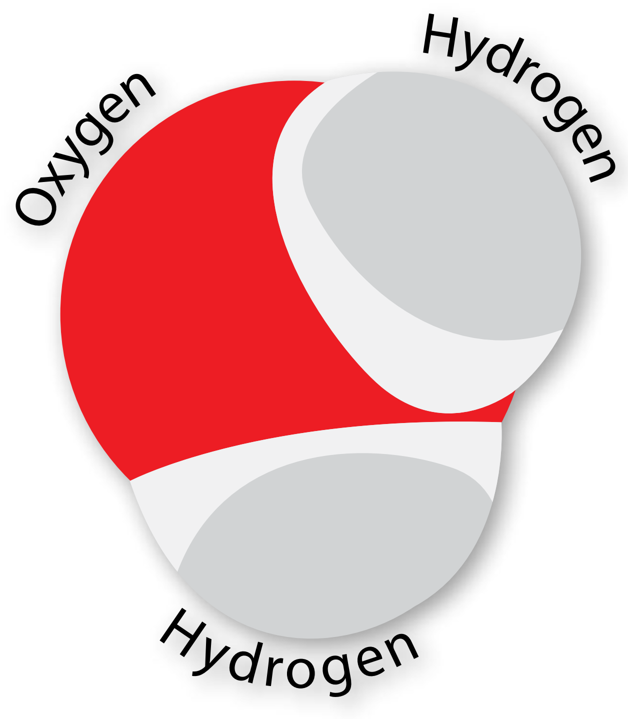
Pure water has a low electrical conductivity, but this increases significantly upon solvation of a small amount of ionic material such as sodium chloride. Water has the second highest specific heat capacity of any known chemical compound, after ammonia, as well as a high heat of vaporization (40.65 $kJ\ mol^{-1}$), both of which are a result of the extensive hydrogen bonding between its molecules. These two unusual properties allow water to moderate Earth’s climate by buffering large fluctuations in temperature.

Water forms an azeotrope with many other solvents. Water can be split by electrolysis into hydrogen and oxygen.

As an oxide of hydrogen, water is formed when hydrogen or hydrogen-containing compounds burn or react with oxygen or oxygen-containing compounds.

Water is not a fuel, it is an end-product of the combustion of hydrogen. The energy required to split water into hydrogen and oxygen by electrolysis or any other means is greater than the energy released when the hydrogen and oxygen recombine.

Elements which are more electropositive than hydrogen such as lithium, sodium, calcium, potassium and caesium displace hydrogen from water, forming hydroxides. Being a flammable gas, the hydrogen given off is dangerous and the reaction of water with the more electropositive of these elements is violently explosive.



The physical make up of water.

Salt Water

Seawater is water from the sea or ocean. On average, seawater in the world's oceans has a salinity of about 3.5%. This means that every 1 kg of seawater has approximately 35 grams of dissolved salts (mostly, but not entirely, the ions of sodium chloride: Na+, Cl-).

Ocean water has a salt content of around 35,000 parts per million (ppm). Humans have a salt taste threshold of around 3,500 ppm. Most chlorine generators require a salt content of 2500 to 6000 ppm in the pool.

Swimming in a mild saline solution is much like taking a shower in soft water. Generally, when people swim in a non-chlorine generator pool (a pool with no salt water in it) they feel like their skin dries quicker upon exiting the pool. They may feel and/or see a whitish residual, chlorine flaking, on the skin. In a salt-water pool (one with a chlorine generator) the water feels smooth, your skin feels smooth and many people feel more refreshed.

A chlorine generator's main function is to produce chlorine for the pool so you do not have to buy it, store it or handle it. These are big advantages for many pool owners. Chlorine generators, when functioning correctly, produce chlorine constantly (when the pump is running) with most units. This keeps a residual of chlorine in the pool that prevents algae from growing.

The secret is keeping the cell free of calcium and mineral deposits. The cell itself is made up of precious metals. It must be maintained so it can continue to make chlorine.

Through the process of electrolysis, water passing over the chlorine generator cell produces chlorine that is instantaneously transformed into hypochlorous acid.

A salt chlorine generator or cell

When any type of chlorine is added to water it all makes the same thing: hypochlorous acid. It does not matter if it is Sodium Hypochlorite (liquid chlorine), Tri-chlor and Di-chlor or Lithium based, Cal-hypo or even gas chlorine, because it all makes hypochlorous acid.

Hypochlorous acid is the active sanitizer; this is what kills algae and other harmful bacteria and viruses in the water. Its effectiveness is totally predicated on balanced water conditions and, more importantly, proper pH.

So, with a salt water system or chlorine generator, you still must maintain your water balance (pool chemistry) properly. As long as you do this, a chlorine generator may be a good choice for a swimming pools disinfectant.

Swimming Pool Water Pollutants

Swimming pool water pollution is mainly caused by swimmers. This makes it a very dynamic pollution, which is dependent on the number and types of swimmers.

Swimming pool pollutants can be divided up into three groups: microorganisms, undissolved pollutants and dissolved pollutants.

Each swimmer carries a large number of microorganisms, such as bacteria, fungi and viruses. Many of these microorganisms may be pathogenic and can cause disease.

Un-dissolved pollutants mainly consist of visible floating particles, such as hairs and skin flakes, but also of colloidal particles, such as skin tissues and soap remains.

Dissolved pollutants can consist of urine, sweat, eye fluids and saliva. Sweat and urine contain water, but also ammonia, ureum, kreatine, kreatinine and amino acids. When these substances are dissolved in water, they cannot harm swimmers. However, when these compounds react with chlorine in swimming pool water, incomplete oxidation can cause chloramine formation.

This causes the so-called chlorine-scent, which irritates the eyes and respiratory system. Chloramines or Combined Chlorine (CC) are more fully covered in a later chapter of this book.

Bird droppings are a major swimming pool pollutant.

Features of Swimming Pool Water

When a swimming pool is filled with water, it is vital that 'balanced' water is maintained to ensure minimal damage to all surfaces, including concrete, tiles, grouting, etc. Water can either corrode such surfaces or deposit crusty, course substances called scale. When the water is either corrosive and/or scale forming, it is called 'unbalanced' water. To ensure that the pool water is not causing any structural damage to the pool, the water must be maintained as 'balanced'.

When the water is corrosive it tends to be extremely aggressive and tends to dissolve concrete, coatings and metals. When the water is corrosive it tends to look stained, whereas scaling water deposits calcium carbonate on pool surfaces, and attempts to plug up the filter and pipes. When the water in a pool is balanced it does not show any of these irritable signs.

Maintaining balanced water not only provides a safe and hygienic environment for the users, but it also limits and avoids any unnecessary maintenance costs.

Swimming pool water is balanced for three reasons:

- **Bather comfort**
- **Protection of plant and equipment**
- **Starting point to add a disinfectant**

To be able to achieve balanced water, the following elements need to be controlled and regulated at predetermined levels: pH, temperature, calcium hardness, total alkalinity and total dissolved solids. Less emphasis is placed on both temperature and total dissolved solids, however the astute pool operator must be aware of the affects that these two factors have on their pool's performance.

Slides add to the fun of going to the local swimming pool.

Recreational swimmers can enjoy a swimming pool without interupting lap swimmers.

pH

Most facility managers would agree that pH is the most important element in pool water management. All chemicals introduced or produced in a pool are either affected by or have an impact on pH.

Invented in 1900's to measure the acidity of water in the brewing of beer, pH stands for 'potens hydrogen' or 'potential of hydrogen ions'. pH is measured on a scale from 0 to 14, with the level 7 being neutral. If the water measures below 7, it is said to be acidic, and if the measurement is above 7, the water is 'basic' or 'alkaline'.

As the pH of the fluid, which surrounds the human eye, measures 7.4 to 7.5, it is recommended that the pH of pools and spas be maintained at this level (or slightly alkaline).

Problems associated with pH:

Low pH (corrosive water)

- Staining walls
- Dissolves metals
- Pitting of concrete
- Chlorine loss
- Skin/eye irritation

High pH (scaling water)

- Cloudy pool
- Plugged filters
- Circulation reduced
- Inefficient sanitisation
- Skin/eye irritation

Temperature

As temperature increases, calcium carbonate becomes less soluble, causing it to precipitate out of solution at higher temperatures. The Langlier Saturation Index gives consideration to temperature as one of the critical factors in obtaining 'balanced' water. As the temperature increases, the water balance tends to become more basic and therefore scale producing. Alternatively, as the water temperature decreases, the water becomes more corrosive. As well as being a considered factor in water balance, water temperature can also impact on water evaporation, algae growth and chlorination.

Problems associated with temperature:

Low temperature

- Corrosive water

High temperature

- Scaling water
- Evaporation
- Algae growth
- Ineffective disinfection

Electric heat pumps are common in large complexes.

Calcium Hardness

Water hardness is caused by the presence of both calcium and magnesium compounds. Because of this saturation of minerals, the ‘hardness’ of water is mainly contributed by the amount of calcium in the pool water. The hardness of the water is actually caused by the movement of water over rocks, soil and other solids. Although ‘soft’ water is often preferred for domestic use, calcium hardened water is actually preferred for swimming pool use. A quick indicator of soft water is that it foams more easily than hard water. A lower level of ‘hardness’ in the pool water has an impact on the ability to balance the water.

Calcium hardness is measured in parts per million (ppm) and has a recommended range of between 200 to 400ppm.

Water that is low in calcium hardness will result in etching and pitting of the concrete in the pool. Metal components of a pool will also deteriorate if the calcium hardness is low.

It is recommended that calcium hardness be tested bimonthly as a minimum.

Problems associated with Calcium Hardness (CH):

Low CH

- Corrosive water
- Pitting of concrete & pool decks
- Dissolving of grout

High CH

- Cloudy water
- Inefficiency of pool heating
- Reduced circulation
- Plugging of filters

Balanced water in a swimming pool will increase the life of plant and equipment.

Total Alkalinity

Total alkalinity is also measured in ppm and is a measurement of the alkaline content of the water. The alkaline components of the water include carbonate, bicarbonate, and hydroxide. The pH and total alkalinity in a pool are closely related and the desired level of total alkalinity to be maintained in a pool, should be in the range of 100 to 150 ppm.

If the level of total alkalinity of swimming pool water is too low, the pH level will be compromised, and this will then impact on the efficiency of disinfectants, particularly chlorine.

Alternatively, if the total alkalinity is too high, it will hold the pH at a higher level and encourage automatic dosing of larger amounts of chemicals.

Problems associated with Total Alkalinity (TA):

Low TA

- Corrosive water
- pH bounce
- Stained walls
- Pitting of concrete
- Dissolving of metals

High TA

- Scaling water
- Cloudy water
- Circulation is reduced
- Filters become plugged
- pH drifts rises

Water clarity is an important physical factor of swimming pool water.

Total Dissolved Solids

Total Dissolved Solids (TDS) is the sum of all the solids contained in pool water. TDS can be caused by a variety of influencing factors including sweat, disinfectants, algaecides, chemicals, dirt and dust blown into the water, calcium hardness, etc. etc.

So realistically, the pool water becomes ‘used’ and it becomes a time when the water needs to be rejuvenated.

To reduce the TDS level in the water simply requires dumping some of the affected water and topping up with new source water or fresh water, that has normal TDS levels.

As an indication, the following water types have a TDS of:

Tap water	200-600ppm
Brackish water	3,000-5,000ppm
Sea water	35,000ppm

TDS has only minimal affect on the Langlier Saturation Index, and is normally a constant reading of –12.1. This is helpful, as measuring the TDS requires an electronic analyser, which is not usually readily available at most pools.

Swimming pool water chemicals are diluted by both sunlight and the wind.

Balanced Water Using the Langlier Saturation Index.

Water balancing is not such a complicated exercise. It is simply the relationship between different chemical parameters. Your water is constantly changing, year round.

Everything from weather to oils, to dirt, and cosmetics affect you water balance. You will probably not change the water in your pool for many years. Continuous filtration and disinfection removes contaminants which keep the water enjoyable but this does not balance your water.

A pool that is "balanced" has proper levels of pH, Total Alkalinity, and Calcium Hardness. It may also be defined as water that is neither corrosive or scaling. This concept is derived from the fact that water will dissolve and hold minerals until it becomes saturated and cannot hold any more water in solution.

When water is considerably less than saturated it is said to be in a corrosive or aggressive condition. When water is over saturated and can no longer hold the minerals in solution it is in a scaling condition. So then, balanced water is that which is neither over or under-saturated. The cliché that "water seeks its own level" certainly applies here. Water which is under-saturated will attempt to saturate itself by dissolving everything in contact with it in order to build up its content.

Water, which is over-saturated, will attempt to throw off some of its content by precipitating minerals out of solution in the form of scale. How do we know when our water is over or under saturated? We use a good test kit (with fresh testing reagents) to measure the chemical parameters of pH, alkalinity, and calcium hardness.

The Saturation Index

Also called the Langelier Saturation Index (LSI), this chemical equation or formula is used to diagnose the water balance in the pool.

The formula is:

"SI = pH + TF + CF + AF - 12.1."

To calculate the Saturation Index, test the water for pH, temperature, calcium hardness, and total alkalinity. Refer to a chart for assigned values for your temperature, hardness, and alkalinity readings then add these to your pH value. Subtract 12.1, which is the constant value assigned to Total Dissolved Solids and a resultant number will be produced. A result between -0.5 and +0.5 is said to indicate balanced water.

Results outside of these parameters require adjustment to one or more chemical components to achieve balance. This formula is not guaranteed; however, some readings for pH, calcium, and alkalinity which, if taken individually would be considered to be well beyond recommendations, can combine within the formula to produce "balanced water." The SI can be used to pinpoint potential water balance problems.

It is important that to calculate the LSI, the three critical test results being Temperature (Temperature Factor or TF), the Calcium Hardness (Calcium Factor or CF) and the Total Alkalinity (Alkalinity Factor or AF) are converted using the following scale.

A swimming pool with the following chemical and physical test results, would indicate balanced water.

Sample Test Results:

pH 7.6
Temperature 26°C
Calcium Hardness 180ppm
Total Alkalinity 120ppm
Total Dissolved Solids - in this example the water source is purified town water*

*Therefore the Total Dissolved Solids or TDS would be read as a norm of -12.1

By taking the sample test results indicated above, and using the formulas in table 2, the LSI test result for this swimming pool would be:

7.6 + 0.6 + 1.9 + 2.1 – 12.1 = 0.1

A final result of 0.1, indicates that the results have finished within the desired range, being between -0.5 and +0.5, therefore the water is 'balanced'.

Swimming pool water is balanced to provide bather comfort, is the stating point to add disinfectant and provides longevity at plant and equipment.

The Langelier SI table						
Table 1 (TF) temperature			Table 2 (CF) calcium hardness		table 3 (AF) total alkalinity	
Degrees F	Degrees C	TF	CH(ppm)	CF	TA(ppm)	AF
32°F	0°C	0.1	5	.3	5	.7
37°F	3°C	0.1	25	1.0	25	1.4
46°F	5°C	0.2	50	1.3	50	1.7
53°F	12°C	0.3	75	1.5	75	1.9
60°F	16°C	0.4	100	1.6	100	2.0
66°F	19°C	0.5	150	1.8	150	2.2
76F	24°C	0.6	200	1.9	200	2.3
84°F	29°C	0.7	300	2.1	300	2.5
94°F	34°C	0.8	400	2.2	400	2.6
105°F	41°C	0.9	800	2.5	800	2.9
128°F	51°C	1.0	1000	2.6	1000	3.0

PPM or mg/l

Metric system units go in steps of 10, 100, and 1,000. A milligram is a thousandth of a gram (moving the decimal point three places to the left) and a gram is a thousandth of a kilogram (again a difference of three places to the left on the decimal point).

Thus, a milligram is a thousandth of a thousandth, or a millionth of a kilogram moving the decimal point six places. So, a milligram is one ppm of a kilogram; therefore, one ppm is the same as one milligram per kilogram.

Parts per million also can be expressed as milligrams per liter (mg/L). This measurement is the mass of a chemical or contaminate, per unit volume of water. Seeing ppm or mg/L on a laboratory report means the same thing. Some other analogies that may help you visualize the scale involved with ppm:

One ppm is like:

•one inch in 16 miles,

•one second in 11.5 days,

•one minute in two years, or

What does ppm mean for the swimming pool industry?

Most chemical dosing rates are expressed as parts per million (ppm).

This means that the concentration of a particular substance is very low even though the regulatory agency (or Health Department) may consider it a significant amount.

One ppm is 1 part in 1 million or the value is equivalent to the absolute fractional amount multiplied by one million.

A better way to think of ppm is to visualize putting four drops of ink in a 55-gallon (208 litres) drum of water and mixing it thoroughly. This procedure would produce an ink concentration of 1 ppm.

Correct dosing rates will ensure that bacteria and viruses are not spread by swimming pool water.

How much water is in the pool?

Understanding the volume of water in a swimming pool is critical to water quality management.

Swimming pools have to be dosed (with water and chemicals) and if an operator does not clearly understand the size of the pool that he is maintaining, then he cannot calculate the exact quantities of chemicals required to meet pre-determined dosing levels.

Quite simply, a cubic metre of water is equal to 1,000 litres of water.

Therefore determining how many cubic metres are in a swimming pool will easily convert to litres (pool volume).

To ascertain the cubic metres, the pool tank can be broken into common shapes eg. squares, rectangles, circles, etc..

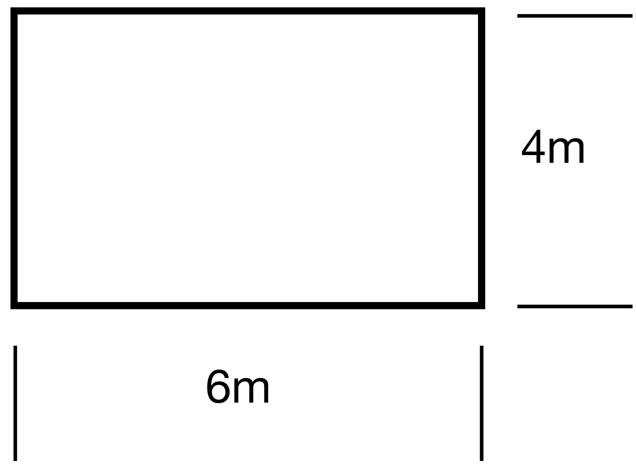
The surface area is calculated in metres cubed, and then multiplied by the depth to give the volume in cubic metres.

The standard length in the metric system is the metre. A millimetre (mm) is one thousandth part of a metre ie.

1 metre = 1000 mm.

Areas are measured in square units, such as square metres or square millimetres, which are written as m2 or mm2.

A rectangle is a four sided figure having each angle equal (90 degrees). A square is a rectangle with sides of equal length. To work out the area of a square, multiple the length of the side, by the length of the other side.

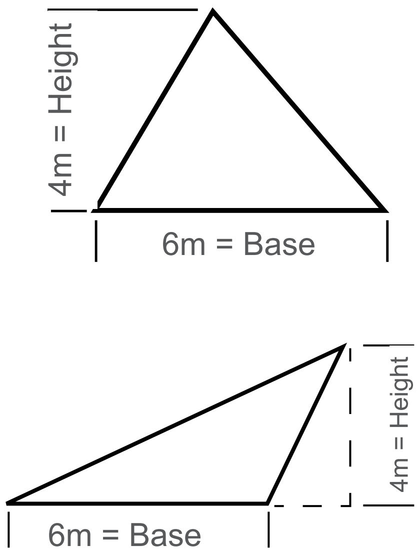


The area of a rectangle is the length multiplied by the breadth. In the example above, the surface area would be calculated by:

6m x 4m = 24 square metres (m^2)

A swimming pool which is 50 metres long x 20 metres wide x 2 metres deep will hold 2,000,000 litres of water.

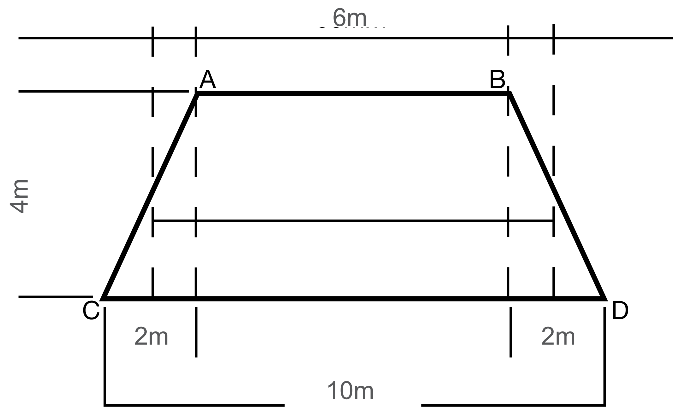
A triangle is a figure having three sides or three internal angles. A right-angled triangle is a triangle where one of the internal angles is at 90 degrees.



The area of a triangle is half the area of a square or rectangle. In the example above, the surface area of a triangular swimming pool would be:

$$\frac{6m \times 4m}{2} = 12m^2$$

A trapezium is a four-sided figure having two sides parallel. Using this figure is particularly helpful when calculating the surface area of a swimming pool with a beach entry.

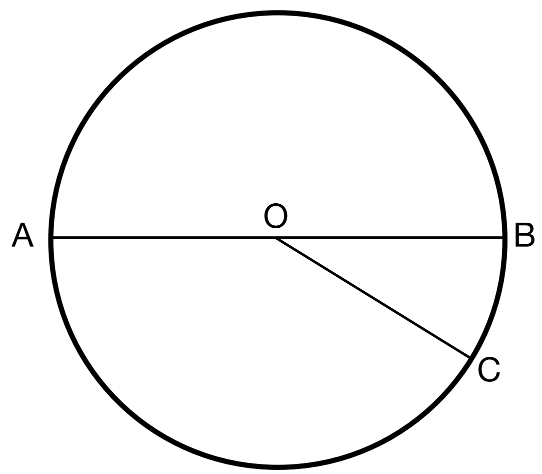


The area of a trapezium is equal to a rectangle plus the area of the two triangles on either side. In the example above, the surface area of this pool would be:

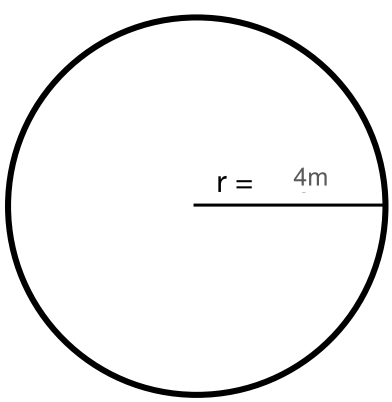
$$6m \times 4m + \frac{4m \times 2m}{2} + \frac{4m \times 2m}{2} = 32m^2$$

Odd shaped pools should be sectioned off into basic shapes for determining water volumes.

A circle is a figure, where the circumference or the outside boundary, is a constant distance from the centre. If a line is drawn through the centre point, where the line touches the circumference on both sides, the distance between is called the diameter. Half the diameter is called the radius.



The area of a circle is equal to πr2.

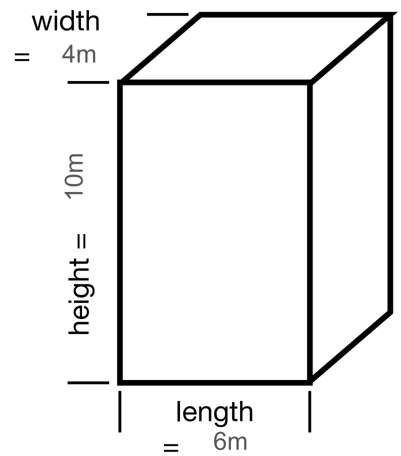


In the example above, where a swimming pool would have a circular shape, the surface area would be:

$\pi \times 4m \times 4m = 50m^2$

Volumes are measured in cubic units eg: cubic metres. A cubic metre is m3. Liquid volumes are expressed as litres. One cubic metre of water is equal to 1000 litres of water.

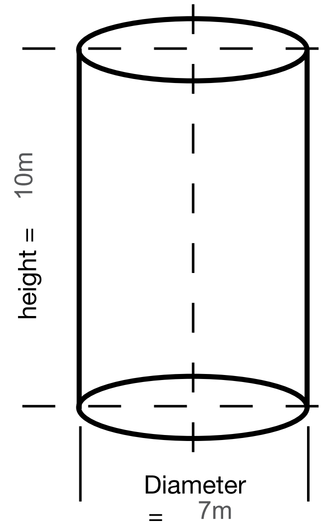
The volume of a rectangular solid is equal to the length x width x height.



The volume of the diagram above would equal:

$6m \times 4m \times 10m = 240m^3$

The volume of a cylinder is equal to the area of the base x height.

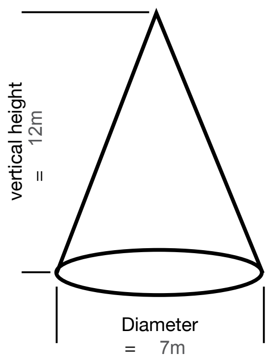


$\pi \times 3.5m \times 3.5m \times 10m = 385m^3$

The volume of a cone is equal to the area of the base x 1/3 of the height.

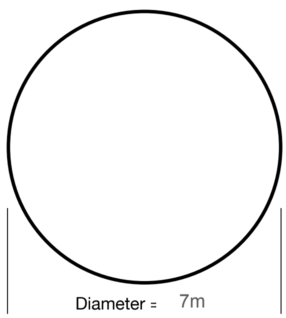
Therefore the volume would be:

Π x 3.5m x 3.5m x (12m/3) = 154m^3



Most swimming pools will have a floor that slopes at 15:1.

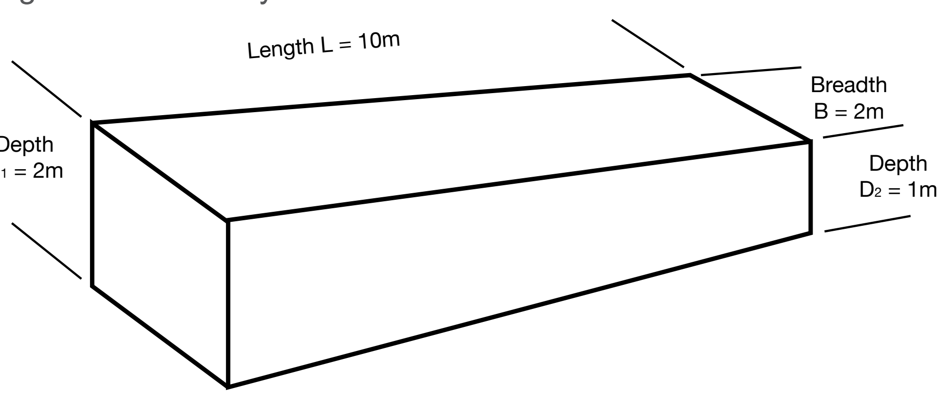
The volume of a sphere is equal to 4/3 x Π x r3.



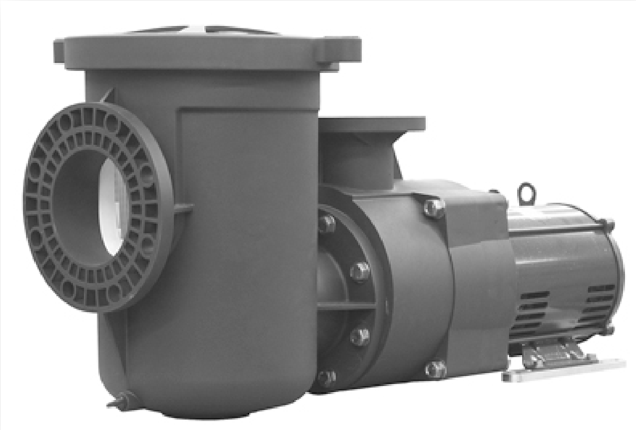
The volume of this sphere would be:

(4/3) x Π x 3.5m x 3.5m x 3.5m = 180m^3

Quite often a swimming pool will have a sloping floor. The gradient is usually 1:15.



$$\text{Vol.} = L \times B \times \frac{D1 + D2}{2}$$



Pumps and pipes.

The Pump

The average swimming pool pump is known as a self-priming centrifugal pump, meaning that the pump houses a vacuum chamber that must be full of water in order for the vacuum to take affect. Hence, the pump sucks water from the pool in order to operate properly.

Self-priming occurs because of the motor and a pump diffuser. The motor drives the pump impeller, the tips of which are securely contained within the pump diffuser. The impeller converts water velocity into water pressure at a rate that is unique to the horsepower of the pump's motor.

Pump Management

There are only a few things to remember when taking care of your pool pump. The pump should be kept free of dirt and debris, and guarded against rainwater and flooding, as this can adversely affect the motor. Additionally, while water must be moved from the pool to the pump, any air infiltration resulting from this process, could damage the pump.

At times, it will be necessary for a pool's sand filter to be backwashed, as the debris caught by the filter can eventually slow water flow. Pressure gauges will indicate whether a backwash is necessary.

A typical lint basket and pump.

The main things to remember in maintaining the pump are:

a) Keep the area surrounding the pump perfectly dry.

b) If the pump is smoking or running 'white' hot, isolate it and call a licensed electrician.

c) If the noise coming from the pump changes pitch, or the pump appears to be 'screaming', again isolate it, and contact a licensed electrician.

d) Maintain a clean lint basket, free from any debris.

e) If a pump requires an electrical connection, this work must be carried out by a licensed electrician.

Filtration

Steel sand filters.

The first known illustrated description of sand filters was published in 1685 by Luc Antonio Porzio, an Italian physician. He wrote a book on conserving the health of soldiers in camps, based on his experience in the Austro-Turkish War. This was probably the earliest published work on mass sanitation. He described and illustrated the use of sand filters and sedimentation.

Porzio also stated that his filtration method was the same as that of “those who built the Wells in the Palace of the Doges in Venice and in the Palace of Cardinal Sachett, at Rome”. The oldest known archeological examples of water filtration are in Venice and the colonies it occupied.

Potential water pollutants are more numerous and varied than you might think. For this reason, swimming pool water must be filtered, to remove the pollutants.

Water Filtration

Before the water enters the pump, it passes through a metal strainer basket that acts as a filter for leaves, sticks and various debris. At this point, the water enters a filter system. There are a few kinds of filter systems, the first is a sand filter system. The water is forced under pressure to the tank’s water distribution head where the filtering truly takes place. The sand particles in the tank act as afiltering mechanism. The water is pulled through the sand, and the sand catches the debris, thus purifying the water. The water is then shot through the outlet pipe and back out.

Some pool systems instead opt for a cartridge filter or diatomaceous earth filter.

Sand Filters

Sand is the oldest and most popular method of filtration. Most sand filters share two things in common:

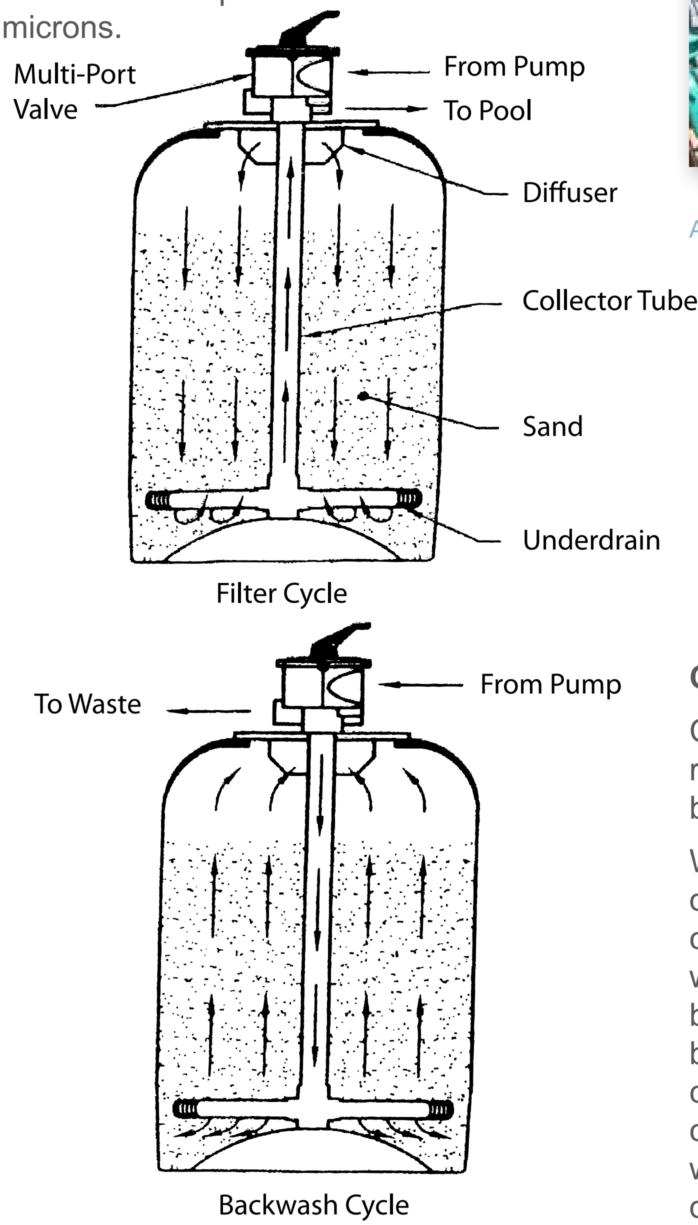
When in filtration mode, water always flows from top to bottom of the filter.

A fibre glass woven sand filter

They all have some sort of lateral or underdrain with slots to hold back sand while allowing clean, filtered water to pass through. High-rate sand filters use a special

POOL ViCi www.vici.com.au

filter sand, normally .45 to .55 mm in size. (also known as pool grade #20 silica sand), They operate on the basis of “depth” filtration where dirt is driven through the sand bed and trapped in the spaces between the sand particles. Initially, a clean sand bed removes larger particles, and then, as the bed starts to load up with debris, the filter removes finer particles. The sand can be cleaned by backwashing, which involves reversing water flow through the filter to the waste. Sand Filters trap debris as small as 20 to 40 microns.



A sand filter showing both the filtration cycle and the backwash cycle.

An efficient sand filter system is easy to manage.

Cartridge Filters

Cartridge filtration has been available for a relatively long time, but has only recently begun to enjoy rapid growth and acceptance.

When water passes through a cartridge filter, dirt is screened out at the surface of the cartridge element. When clean, the element will trap larger particles, with finer particles being filtered out as the pores of the element become clogged by the larger debris. The cartridge element can be removed and cleaned by pressure washing inside and out with a hose. Cartridge element filters trap debris as small as 10 to 15 microns.

Cartridge for a cartridge filter

DE Filters

Diatomaceous earth is a porous powder with microscopic openings that under the microscope look like tiny sponges. Clear water can pass through these openings, but particles, as small as two to five microns, are trapped during the first pass through the media. D.E. filters have internal elements that become coated with D.E. It is this 'filter cake' that strains dirt, dust and algae from the water.

Similar to sand filters, when D.E. filters become dirty, they are cleaned either by backwashing, or regenerating and draining the clogged D.E. to waste. To restore filtration, a fresh 'charge' of D.E. is added to the filter.

Gravity Sand Filters

The Self Cleaning Autonomous Valveless Gravity Sand Filter consists of a 3-compartment vertical steel tank divided into a backwash storage compartment, a filter-bed compartment and a filtrate collection compartment. It operates entirely without any outside energy supply, whereby water is clarified solely through the process of sand filtration. Backwashing occurs on the loss of head principle. The design eliminates the need for backwash pumps and valves.

The backwash storage compartment is designed to hold an adequate amount of backwash water. It always fills to the same height thus providing a constant backwash volume. Also, as the level of water in the backwash compartment drops, the backwash rate diminishes, so that the backwash rate actually starts at about 44 m/h and gradually slows down to 30 m/h at the end. Extensive experience with this diminishing backwash rate has indicated it to be completely satisfactory for cleaning the filter bed. The high initial flow rate provides greater initial turbulence to wash the sand. The lower flow at the end of backwashing permits the bed to settle evenly and smoothly.

The filter-bed compartment contains fine filter sand. Unique strainers uniformly collect the filtered water and distribute the backwash water without the need for any gravel layer.

Experience has shown that under these conditions a surface wash and/or an air backwash is not required to break the surface mat to achieve effective regeneration of the filter bed.

Backwash

Cleaning a filter involves several steps. First, the filter is taken off line and the water is drained down to the filter bed.

Then, the air wash cycle is started which pushes air up through the filter material causing the filter bed to appear to boil. This breaks up the compacted filter bed and forces the accumulated particles into suspension. After the air wash cycle stops, the backwash cycle starts with water flowing up through the filter bed.

Clean water is passed through the filter bed in order to wash the material and remove most of the accumulated particles. This cycle continues a fixed time or until the turbidity of backwash water is below a set value.

In some cases, the additional step of air/water wash (simultaneously) is done after air wash cycle and followed by rinse water wash. These use less water compare to traditional step and have higher removal efficiency which result the cleaner filter.

Backwashing is a form of preventive maintenance to prevent further clogging of the filter medium. Backwashing in water treatment plants is an automated process, usually run by programmable logic controllers (PLCs). The backwash cycle is usually triggered when the differential pressure over the filter exceeds a set value.

A backwash water recycle unit.

Rinse Cycle

Following the backwash cycle and after the water runs clear (usually 2-3 minutes), the pump is turned off and the valve is rotated to the rinse position.

The rinse position directs water from the top of the filter to the bottom, but not back to the pool.

This process compacts the sand and causes any remaining dirt to be flushed out the waste pipe, rather than back to the pool (usually 30-45 seconds).

Once the rinse cycle is completed, the pump is turned off and the multi-port valve is returned to the normal or filter position. Once again turn on the pump and the water is returned to the pool.

The clear poly pipe is the sight glass for the backwash water, which will show the water reducing in turbidity as the backwash cycle is completed.

Disinfectants

A swimming pool's design and use will determine the type of disinfectant used.

Chlorine is one of the most commonly used disinfectants for water disinfection. Chlorine can be applied for the deactivation of most microorganisms and it is relatively cheap.

Chlorine gas was presumably discovered in the thirteenth century. Chlorine (Cl2) was first prepared in pure form by the Swedish chemist Carl Wilhelm Scheele in 1774. Scheele heated brown stone (manganese dioxide; MnO2) with hydrochloric acid (HCl). When these substances are heated the bonds are broken, causing manganese chloride (MnCl2), water (H2O) and chlorine gas (Cl2) to form.

Scheele discovered that chlorine gas was water-soluble and that it could be used to bleach paper, vegetables and flowers. It also reacted with metals and metal oxides. In 1810 Sir Humphry Davy, an English chemist who tested fundamental reactions of chlorine gas, discovered that the gas Scheele found must be an element, given that the gas was inseparable. He named the gas 'chlorine' (Cl), after the Greek word 'chloros', which means yellow-greenish and refers to the color of chlorine gas.

Chlorine can be found on many different locations all over the world. Chlorine is always found in compounds, because it is a very reactive element. Chlorine can usually be found bond to sodium (Na), or in kitchen salt (sodium chloride; NaCl).

Most chlorine can be found dissolved in seas and salty lakes. Large quantities of chlorine can be found in the ground as rock salts or halite. In the periodic chart chlorine can be found among the halogens. Other halogens are fluorine (F), bromine (Br), iodene (I) and astatine (At).

Chlorine can form very stable substances, such as kitchen salt (NaCl). Chlorine can also form very reactive products, such as hydrogen chloride (HCl). When hydrogen chloride dissolves in water it becomes hydrochloric acid. The hydrogen atom gives off one electron to the chlorine atom, causing hydrogen and chlorine ions to form. These ions react with any kind of substance they come in contact with, even metals that are corrosion resistant under normal circumstances. Concentrated hydrochloric acid can even corrode stainless steel. This is why it is stored either in glass or in plastic.

Chlorine is a very reactive and corrosive gas. When it is transported, stored or used, safety precautions must be taken.

Liquid chlorine should be protected from sunlight. Chlorine is broken down under the influence of sunlight. UV radiation in sunlight provides energy, which aids the break-down of underchloric acid (HOCl) molecules.

Chlorine is produced from chlorine bonds by means of electrolytic or chemical oxidation. This is often attained by electrolysis of seawater or rock salt. The salts are dissolved in water, forming brine. Brine can conduct a powerful direct current in an electrolytic cell. Because of this current chlorine ions (which originate from salt dissolving in water) are transformed to chlorine atoms. Salt and water are divided up in sodium hydroxide (NaOH) and hydrogen gas (H2) on the cathode and chlorine gas on the anode. These cathode and anode products should be separated, because hydrogen gas reacts with chlorine gas very aggressively.

The chemical industry creates ten thousands of chlorine products using a small number of chlorine containing chemicals. Examples of products which contain chlorine are glue, paints, solvents, foam rubbers, car bumpers, food additives, pesticides and antifreeze. One of the most commonly used chlorine-containing substances is PVC (poly vinyl chloride). PVC is widely used, for example in drainpipes, insulation wires, floors, windows, bottles and waterproof clothes.

Chlorine-based bleach is applied as a disinfectant on a large scale. The substances are also used to bleach paper. Bleaching occurs as a result of chlorine or hypochlorite oxidation.

Chlorine has been used for applications, such as the deactivation of pathogens in drinking water, swimming pool water and wastewater, for the disinfection of household areas and for textile bleaching, for more than two hundred years.

When chlorine was discovered we did not now that disease was caused by microorganisms. In the nineteenth century doctors and scientists discovered that many diseases are contagious and that the spread of disease can be prevented by the disinfection of hospital areas.

Very soon afterward, we started experimenting with chlorine as a disinfectant. In 1835 doctor and writer Oliver Wendel Holmes advised midwifes to wash their hands in calcium hypochlorite (Ca(ClO)2-4H2O) to prevent a spread of midwifes fever.

A chlorine storage tank

However, we only started using disinfectants on a wider scale in the nineteenth century, after Louis Pasteur discovered that microorganisms spread certain diseases. Chlorine has played an important role in lenghthening the life-expectancy of humans.

The cell wall of pathogenic microorganisms is negatively charged by nature. As such, it can be penetrated by the neutral underchloric acid, rather than by the negatively charged hypochlorite ion. Underchloric acid can penetrate slime layers, cell walls and protective layers of microorganisms and effectively kills pathogens as a result.

When chlorine is added to water for disinfection purposes, it usually starts reacting with dissolved organic and inorganic compounds in the water. Chlorine can no longer be used for disinfection after that, because is has formed other products. The amount of chlorine that is used during this process is referred to as the ‘chlorine enquiry’ of the water.

An automatic dosing unit used to inject chlorine into the pool water system

Chloramines or Combined Chlorine

Chloramines are the result of insufficient free chlorine and usually result in a strong chlorine odor in and around the swimming pool. Chloramines are formed as a product of nitrogen and active chlorine (hypochlorous acid - HOCl). The nitrogen is most commonly introduced into the pool water as ammonia in the form of sweat and (unfortunately) urine.

Chloramines (combined chlorine) are poor sanitizers and have a gaseous tendency. The presence of chloramines (and dichloramines/trichloramines in particular) cause the following physical symptoms:

1. red, burning eyes;
2. burning sensation in nose, throat and lungs;
3. dry, itchy skin and dry hair;
4. breathing difficulty leading to "swimmers' asthma" particularly in young children.

In addition to these, the pool has a tendency to discolor, becoming milky or green with algae due to the low sanitizing ability of the combined chlorine.

Testing for combined chlorine in pool water

All good chlorine test kits and pool test strips allow you to determine free chlorine as well as total chlorine. Combined chlorine is calculated from these values as follows:

combined chlorine = total chlorine - free chlorine

The combined chlorine value should never exceed 50% of the free chlorine value and should ideally be as close to zero as possible.

A shock treatment using either chlorine or a non-chlorine sanitizer will ensure the destruction of the nitrogen compound combined with the chlorine. The pungent smell disappears and the free chlorine level goes up providing complete sanitization of the pool water.

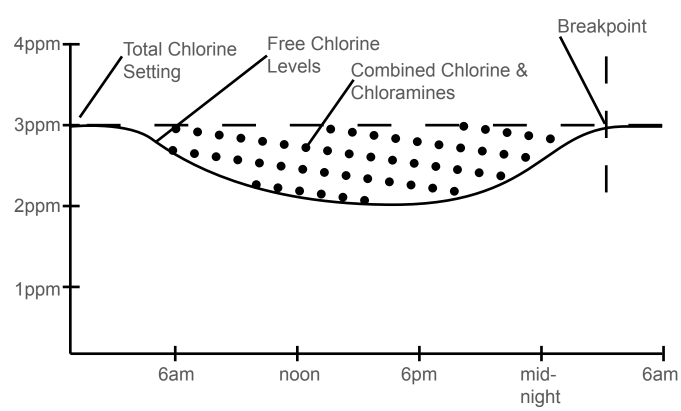
Break Point

When you start to smell "chlorine", what you are really smelling are chloramines. Chloramines are chemical compounds formed by chlorine combining with swimmer wastes such as sweat, urine, body oil, etc. Chloramines are non-effective as a disinfectant and will cause eye and skin irritation.

The chloramine level is calculated by subtracting the free chlorine from the total chlorine in the pool/spa water.

Breakpoint chlorination consists of a continual addition of chlorine to the water up to the point where the chlorine enquiry is met and all present ammonia is oxidized, so that only free chlorine remains.

This is usually applied for disinfection, but it also has other benefits, such as smell and taste control. In order to reach the breakpoint, a super-chlorination is applied. To achieve this, one uses chlorine concentrations which largely exceed the 1 mg/L concentration required for disinfection.



A typical cycle of chlorine levels over a 24 hour period.

Ozone

In essence, ozone is nothing more than oxygen (O2), with an extra oxygen atom, formed by an electric charge. In nature, ozone is produced by chemical reactions. The most familiar example is of course the ozone layer, where ozone is produced from the sun's ultra-violet (UV) rays.

But ozone is also produced at thunderstorms and waterfalls. The extreme high voltages associated with thunderstorms produce ozone from oxygen. The special "fresh, clean, spring rain" smell is a result from nature-produced ozone. Ozone derives from the Greek word "ozein", which means "to smell". Ozone is only produced under extreme circumstances. This can also be created by ozone generators. Ozone generators produce ozone with extreme high voltages or with UV-light.

The use of ozone to disinfect swimming pools and spas has been a common practice for over 50 years. In the past five years, the pool and spa industry has become increasingly interested in ozone as a supplemental disinfectant to traditional chlorine and bromine-based water treatment. The reasons behind this include a need to provide exceptional water clarity with minimum chlorine odor and bather discomfort.

The use of an ozonation system that is properly sized and integrated into the swimming pool treatment system will allow ozone to act as the primary oxidizer and disinfectant. Ozone is fed into the pool feed water prior to the chlorine injection process. Ozone destroys many organic compounds and microorganisms that would typically react with chlorine, resulting in a reduction of the chlorine demand and total dissolved solids. Lower chlorine demand allows the pool operator to achieve disinfection of the water with minimal chlorine residual, and the reduction of total dissolved solids improves the water clarity. The reduction of chlorine usage will minimize the amount of chlorine off-gas that causes corrosion in swimming pool environments. Ozone will also break down chloramines, a major cause of the odor and eye irritation associated with swimming pools.

Ozone is one of the strongest oxidation agents technically available for use to oxidize solutes. The extra-added oxygen atom will bind (=oxidation) in a split second to every component that comes into contact with ozone. Ozone can be used for a broad area of purification. For the biggest part ozone is applied in the municipal wastewater and potable water treatment plants (for disinfection). The main benefit of ozone is its clean character, because it only oxidizes materials, while forming almost no byproducts.

Ozone can be produced artificially according the same principle as it occurs in nature, which means by UV light (ozone layer) or via corona-discharge (high voltages, thunderstorm).

Because of its short half-life, ozone will decay soon after being produced. The half life of ozone in water is about 30 minutes, which means that every half hour the ozone concentration will be reduced to half its initial concentration. For example, when you have 8 g/l, the concentration reduces every 30 minutes as follows: 8; 4; 2; 1; etc. In practice the half-life is shorter because a lot of factors can influence the half-life.

At higher concentrations ozone is harmful for human health after inhalation. When people are exposed to high ozone concentrations the symptoms can vary from dryness in the mouth and throat, coughing, headache and chest restriction.

Ionisation

Silver acts as a disinfectant when dissolved in water as ions. Similarly, copper ions, prevent algae growth. These metal ions are generated in the pool water through the electrolytic dissolving of silver/copper alloy electrodes.

An ioniser is an ion-generating device, which is installed in the circulation system. The devise consists of two units. The electrode assembly
(a copper electrode & a silver electrode), and the electronic control unit. The control unit supplies an electric current to the electrodes which, through the process of electrolysis, pass either silver or copper ions into the water.

UV Treatment System

UV Water Purification

Ultraviolet treatment of pool water photo-ozidizes and destroys combined chlorine and other pollutants, giving major improvments to pool environment and water quality, with significantly lower levels of chlorine. UV also provides non-chemical disinfection, giving effective primary control over waterborne bacteria, benefiting commercial and municipal pools. Spa and hot tub establishments present difficult disinfection problems due to the high bather load and temperature. Until recently public pool operators have had little choice but to use chlorine disinfection systems, sometimes together with an ozone oxidation process. The UV water purification systems have proved that ultraviolet treatment with low levels of free chlorine has major benefits over any of these traditional methods. The greatest benefit of UV treatment is that short-wave ultraviolet light has a photo-oxidation effect that destroys chloramines and other toxic by-products of chlorine. This is done without adding any further chemicals to the water. Much less chlorine needs to be used to provide bacterial control, so water quality and atmospheric conditions are considerably improved. The primary UV disinfection process destroys all bacteria passing through the water treatment plant. In particular, and unlike ozone systems, this protects bathers against bacteria in the water filter media re-entering the pool.

Algae growth will be evident as the disinfectant levels decrease.

Algae

Algae is a small plant growth which can take on many forms and is closely related to seaweed which itself is a form of algae. As in the case of seaweed, it can come in many shapes and sizes but for the most part algae found in swimming pools is very small and resembles moss. These tiny microscopic plants feed on nutrients contained in the water. The algae spores, or seeds if you like, are either already present in the water, transported to the pool by wind or are attached to other debris which finds its way into the pool.

The algae plant requires only air, sunlight, water and a good supply of nutrients to grow. They normally grow most profusely in the shallowest water and are usually found in areas around swim-outs and steps.

By removing any one of the elements mentioned before ie. air, sunlight, water or nutrients, the algae will not grow. The simplest way of ridding your pool of algae is to remove the nutrients required for algae growth. Shock dosing of the pool will usually overcome the problem by starving the algae of its nutrients, causing it to die.

However they are extremely hardy little organisms and, in some cases the algae becomes so resistant to the normal sanitiser that treatment with an algaecide is required. Once the algae dies, the residue will need to be brushed from the pool surface so it can be removed by the filtration process or vacuumed out, leaving the pool clean and clear.

Maintaining correct water balance and sanitiser level and not allowing the pool to “go off”, along with occasional shock dosing, will usually keep algae under control. Add to this the regular use of an Algaecide and you can be sure the pool remains clean and free from algae.

Testing Pool Water

To ensure that the water in a swimming pool is safe and hygienic for use, it is necessary to test the different chemical factors and levels, and to verify that the proper ranges are being maintained. Procedures have been established by manufacturers of water test kits and these must be explicitly followed to provide accurate results from the sample.

Colorimetric measurement is made by comparing colours with the sample water, after indicators have been added. The colour of the water sample is then matched with a table or series of determined colour standards.

The drop titration measurement indicates the concentration of chemical in the sample water by adding a re-agent drop by drop. The latter reagent is referred to as the titrant, and it is added until a colour change occurs to the indicator, which is then said to be the endpoint of the titration. Each individual drop of the titrant is equivalent to a predetermined level or a given quantity of chemical. The number of drops is then multiplied by the predetermined concentration of the chemical. (eg…….. after each drop, count and swirl to mix until colour changes from red to blue. Multiply the number of drops by 10. Record as parts per million calcium hardness as calcium carbonate…….)

Some basic rules must be observed, when taking and testing water samples:

1. Never test the pool water on the surface. Take the sample from around 450mm under the surface.
2. Do not test the water near the returns from the pool plant.
3. Test re-agents have a “use by” date.
4. Test re-agents should be stored in a cool shaded area.

A typical water sample test kit.

Records

Pool test and maintenance recording is essential. Shrouded with the constant potential for litigation and blame, record keeping must be a high priority for all aquatic facility managers.

Some government authorities eg. Health Departments, provide a guide for how often pool tests should be taken and recorded.

Facility Managers should assess the need for the regularity of their own tests, and they must ensure that any likely sudden changes in bather numbers can be managed.

Two of the high priority tests are Free Chlorine and pH. Both of these readings will provide a basis for assessing the critical condition and health of the pool water.

Other elements to monitor include Total Chlorine, Combined Chlorine (chloramines), Total Alkilinity (TA), Calcium Hardness (CH), Temperature, Total Dissolved Solids (TDS) and the Langlier Saturation Index (LSI) or water balance.

Water test sheets are provided as part of this workbook.

It is important to realise however, that different test kits used on the same water sample, may give a variance in the reading. It always pays, to have access to a second reliable testing source eg. the local swimming pool shop.

Sample pool operator log sheet

Time						
Measurements						
Free Chlorine						
Combined Chlorine						
Total Chlorine						
pH						
Redox (mv)						
Electronic Chlorine						
Electronic pH						
Temperature						
Total Alkalinity						
Calcium Hardness						
Total Dissolved Solids						
Langelier Index						
Cyanuric Acid						
Adjustments / Additions						
Disinfectant						
pH Correction						
Bicarbonate						
Alum / Coagulant						
Others						
Others						
Observations						
Filter Pressures						
Backwashes Done						
Clarity						
Make Up						
Bather Load						
Water Meter Reading						
Backwash (Litres)						
Dilution (Litres)						
Operator's Initials						

What chemicals to add.

The dosing chart referred to as fact Sheet on page 90 will assist facility managers with their dosing calculations.

Remember to always dose in small amounts and test. There must be a firm understanding of the pool volume, right from the beginning, so that any adjustments in chemical dosing can be calculated exactly.

There are a few key chemicals that will need to be stored in close proximity to the plant room. These are also shown on the chemical dosing spread sheet featured on page 90.

Dosing rates have been calculated in ppm and are based on the amount required per 100,000 litres of water.

Chemicals should be bunded separately.

Winterisation (Pool shut down)

Ideally, your closing starts a week before you actually get down to putting the cover on.

You will have to decide if you are going to empty the pool or leave it full of water. You will need to know the pool's structure before you make this decision. Some pools can be emptied but others rely on the internal pressure of the water for the shell to remain in tact. Emptying some pools may result in the shell popping out of the ground.

Other destruction that could be caused may include the seperation of slab joins, tiles coming unstuck, damage to pool surfaces or corrosion to plant and equipment through the introduction of air to the key mechanical components.

If the pool is going to be left full of water, you should:

1. Clean the pool.
2. Cover the pool.
3. Add an algaecide.
4. Turn the pumps onto 1/3 of their normal running.
5. Balance the water in the pool.
6. Maintain the Free Chlorine level at 0.5 to 1.0 ppm.

If you decide the you want to drain or empty the pool, the following procedures should be followed:

1. Vacuum the pool.
2. Clean the pools scum lines.
3. Allow the chlorine levels to drop to 0.0 ppm.
4. Advise the Local Government Authority that you plan to empty the pool.
5. Drain the pool, filters and the lint baskets.
6. Clean the pool basin with a gerney.
7. You should then monitor the pool for any movement in the shell.

An algacide should be added to the water to prevent algae growth.

Pool covers will reduce any pollutants entering the pool during shut down.

Heating

Taking into consideration the need to conserve energy, and to minimize fuel consumption, any unnecessary pool heating should be avoided. You are the best judge of the kind of use you want out of your pool. Use of your pool for recreation, exercise, therapy or just general enjoyment obviously will require heating it. Your pool won't contribute to your health or pleasure unless it's warm enough to swim in comfortably- and when you want to swim.

The temperature recommended for recreational and competitive sports swimming is between 26ºC and 28ºC. This comfort level coincides with good fuel conservation practice, too.

Young children, the elderly and others often need 30ºC or warmer water, however, and hydrotherapy calls for even warmer water again, around 32ºC.

Although 26ºC to 32ºC takes in about everyone, how warm you should keep your pool actually depends on personal preference.

The sun alone usually can't keep your pool water at that comfort minimum of 26ºC. By having a heater to warm your water you can add substantially to the daily use of your pool-and you can also extend the so-called swimming "season".

You can stretch your pool season by twice in most areas and even longer in other areas by having a heated pool.

Pools that are not covered can lose a lot of heat overnight in most parts of the country. With a cover, you can reduce that heat loss by 50% or more.

Remember that besides air temperature, you must consider such variables as wind speed and humidity, both of which affect the rate of heat loss from the pool. If your pool is not covered, protect it from breezes as best you can with walls.

By heating your pool, you make it possible to engage more often in swimming exercise because you extend the hours and the season your pool may be used.

First, there is the initial or one-time cost of the heater you select, and its installation charge. Second, there is the monthly fuel cost, which varies with the type of heating, the use of your pool, the pool water temperature you prefer and other variables. Third, there is the matter of annual maintenance and service.

Operating costs can be kept to a minimum by installing an efficient, properly sized heater; using a good quality pool cover; and, of course, keeping your filter clean and your heating and filtering system well maintained.

Besides stopping heat loss, a cover saves on pool chemicals, too, by keeping them from evaporating with the water.

One of the most widely used types is the direct fired natural gas heater because of its low cost, reliability, ease of operation and the wide availability of natural gas. In areas where natural gas is not available, heater models can use LP gas or propane gas.

Oil-fired pool heaters are a good choice in areas where natural gas is unavailable but home heating oil is.

Electric heaters are generally much less efficient and more costly to operate than natural gas heaters, unless the electricity is hydroelectrically generated.

Solar heating ranges from simple "passive" solar - the familiar pool cover that absorbs and transmits some of the sun's energy to pool water - to "active" solar heating systems.

Used alone, the passive heating technique merely serves to help keep pool temperatures at existing levels by retaining natural solar heat and preventing its loss. It cannot add heat to build up water temperature beyond what the sun supplies. Active solar uses traditional pool motors to move water from the pool through a system of solar collector panels for heating by the sun. This increases the amount of solar heat added to the pool.

An adequate solar pool heating system will cost substantially more initially than fuel-fired heaters. It can add 25% to 50% to the cost of building a pool.

Solar systems have definite limitations. To begin with, they require sufficient area in which to install large collector panels, usually on a roof or deck overhang near the pool.

Solar heating systems heat slowly - and not at all in cloudy, cool periods. Depending on the collector size and your location and climate, a solar system may not be able to warm the water to your desired temperature, even in the swimming season, except in the afternoon.

Heaters are sized mainly on the basis of the pool surface area and the difference between the pool and air temperatures. The average air temperature for the coldest month of pool use is used in the calculation.

Salt water is highly corrosive, and a heater must be equipped with a special heat exchanger and other features to handle it.

Electric heat pumps provide a great source for heating swimming pool water.

Solar panels installed on the roof of an amenities block.

Control of micro-organisms

Pathogenic micro-organisms such as bacteria, protozoa, and viruses may occur naturally in recreational waters. In addition, they may be introduced into swimming pools by bathers or through faulty connections between the filtration system and the sanitary sewer. Proper treatment of swimming pool water is essential for prevention of diseases spread by micro-organisms.

Traditionally, chlorine and chlorine compounds have been used to disinfect swimming pool waters. Free available chlorine (FAC) levels of 1.0 parts per million (ppm) or greater are usually maintained to ensure effective control of micro-organisms and to make acceptable the general sanitary quality of swimming pool waters. Although an effective disinfectant, chlorine has several disadvantages. The lifetime of the FAC residual varies with climatic conditions and bather load (chlorine demand). When chlorine reacts with organic compounds and nitrogen compounds present in the water, it forms objectionable by-products such as trihalomethanes (THMs) and chloramines. FAC levels of 0.6 ppm or greater have been associated with irritation of eyes, nasal passages, and skin, as well as with objectionable odors in the pool environment. Also, chlorine has a corrosive effect on pool structures, necessitating expensive maintenance work.

Other studies have documented the use of copper/silver ions in conjunction with low levels of chlorine to inactivate micro-organisms. In addition to controlling bacteria and viruses, metal ions in part per billion (ppb) concentrations are effective in controlling algae and fungi. Copper and silver ion disinfection has several advantages over chlorine. The ions are chemically stable and do not undergo the destructive reactions of aqueous chlorine, nor do they escape from the water by volatilization as chlorine does. In addition, the metal ions do not form objectionable byproducts such as chloramines or THMs, and they do not exhibit the corrosive properties of chlorine.

Electrolytic generation of copper/silver ions in swimming pool water allows ppb concentrations to be maintained in a convenient and reproducible manner. Regulating the current to the metal electrodes that generate the ions, as well as the flow rate of water passing between the electrodes, enables precise control of metal ion concentrations.

Efficient water turn over in a swimming pool is critical.

Pool Safety

The Royal Life Saving Society – Australia (RLSSA) recommends a number of safety guidelines and risk management systems for all aquatic environments, in their concerted effort to supporting a water safe community.

As partners with many other national and international aquatic industry peak bodies, RLSSA works to improve safety and risk management standards.

The key risk management activities of RLSSA include:

- Guidelines for Safe Pool Operation
- Guidelines for Water Safety
- Aquatic Safety Services
- Australian Lifeguard Network

For all water safety needs, regarding swimming pool management, contact the Royal Life Saving Society – Australia.

Lifeguard supervising children's play area.