Swimming Pool Operation & Maintenance

Background

Swimming Pools can quickly become one of the major headaches for any facility manager. Outside of the potable water supply, few amenities can evoke such emotion from the user as the pool that is not sparkling, crystal clear, and inviting. No two swimming pools are the same, since no two water supplies and environments are the same. Swimming pool operation and maintenance is equal parts science and art, requiring daily attention and usable information. All swimming pools must be routinely maintained and the water tested before changes should be made.

Pool Maintenance Schedule

Daily

1. Note the water clarity and color
2. Test the chlorine level and adjust if needed
3. Test the pH and adjust if needed
4. Clean skimmers
5. Remove surface debris

Weekly

1. Clean pump strainer basket(s)
2. Brush and/or vacuum the entire pool or run pool cleaner
3. Check pressure drop across filter and backwash/clean the filter if needed
4. Test the Total Alkalinity (TA) level and adjust if needed
5. Test the Calcium Hardness (CH) level and adjust if needed
6. Add water if needed

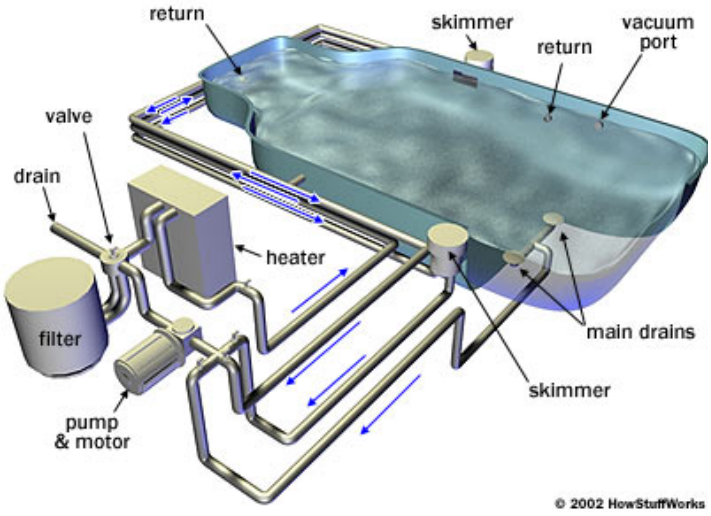
Spring, mid-summer (following substantial water replacement)

1. Test the Cyanuric Acid (CYA) level and adjust if needed
2. If you use salt, test the salt level and adjust if needed
3. If you use borates, test the borate level and adjust if needed

On-Line Swimming Pool Operator Training Course

Certified Pool Operator (CPO)
National Swimming Pool Foundation (NSPF) 4775
Granby Circle Colorado Springs, CO 80919-3131
Phone: 719-540-9119
E-mail: media@nspf.org

Certified Pool Technician (CPT)
Aquatic Training Institute
P.O. Box 141797
Gainesville, FL 32614
http://www.aquatictraininginstitute.com
Phone: 800-385-0270
E-mail: Tom@aquatictraininginstitute.com



Chlorinators, whether tablet, automatic feed, or salt water generators are typically located on the pool return water line after the water has passed through the filter(s) and/or heater.

Swimming Pool Chemicals Summary	
Property / Typical Concentration	**Notes / Tests**
Free Chlorine (FC) Specific chlorine levels depend on the concentration of Cyanuric Acid (CYA) in the pool. Normal: 3 – 12 mg/l Shock: 10 – 39 mg/l	Test Using: DR 890 Colorimeter Free chlorine is the concentration of disinfecting chlorine available to maintain a sanitary pool. FC should be tested and chlorine added daily unless an automatic feeder or Sea Water Chlorine Generator (SWG) is used, in which case, FC should be tested every couple of days. FC is consumed by sunlight and by the breaking down of organic material in the pool.
	To Lower Concentration
	If you are in a hurry you can lower FC with a chlorine neutralizer (sodium thiosulfate).
	To Raise Concentration
	FC is raised with: -Bleach -Liquid chlorine -Liquid shock -Trichlor (tablets/pucks/sticks) -Dichlor powder -Calciumhypochlorite “Cal-hypo” (powder/capsules) -Lithium hypochlorite Only use bleach without any additives, typically labeled unscented or "original scent". Trichlor and dichlor also add CYA and lower pH. Cal-hypo also adds calcium. Lithium hypochlorite tends to be quite expensive. It is most efficient to raise the FC level in the evening, since none will be lost to sunlight until the next morning. FC normally goes down by itself.
	Notes / Tests
Total Chlorine (TC) Range: 0.5 – (FC+0.5)mg/l	Test Using: DR 890 Colorimeter The TC concentration level is many times assumed to be the FC because Combined Chlorine (CC) is usually zero. However when you have algae or some other problems, CC levels can be significant and TC concentrations are no longer a reliable measure of FC.
	Notes / Tests
Combined Chlorine (CC) CC = TC – FC	Test Using: Mathematical Calculation There can be an odor problem if CC > 0.5 mg/l. If CC exceeds 0.5 mg/l, shock pool. Combined chlorine is an intermediate breakdown product that is created in the process of sanitizing the pool. CC causes the "chlorine" smell many people associate with chlorine pools. In an outdoor pool, CC will normally stay at or near zero as long as you maintain an appropriate FC level and the pool gets some direct sunlight.

Total Alkalinity (TA) Non-SWG 70 – 90+ mg/l SWG 60 – 80 mg/l	**Notes / Tests**
	Test Using: 5-in-1 Test Strips Don't lower just to meet a target. Lower to limit a pH rise or to lower the Calcium Scaling Index (CSI)
	To Lower
	Add acid to lower pH & Alkalinity, then aerate to raise the pH
	To Raise
	Add Baking Soda
Calcium Hardness (CH) Vinyl: 50–300 mg/l Plaster: 250–350 mg/l Fiberglass: 220–320 mg/l	**Notes / Tests**
	Test Using: Drop-Count Titration
	To Lower
	Add calcium chloride or calcium chloride dehydrate
	To Raise
	Dilution or Reverse Osmosis
Cyanuric Acid (CYA) 30 – 50 mg/l for SWG pools or those in low direct sunlight 70 – 80 mg/l for non-SWG pools or those in direct sunlight	**Notes / Tests**
	Test Using: DR 890 Colorimeter Sample may require dilution if concentration > 55 ppm
	To Lower
	Dilution
	To Raise
	Add Cyanuric Acid
Borate 30 – 50 ppm	**Notes / Tests**
	Test Using: Test Strip & Drop-Count Tests available to test for Borate Borates can be used to control pH drift due to a SWG or high aeration levels. Borates also help to control algae. Various subjective water quality/feel improvements are also attributed to borates. If you are not intentionally using borates, there is no need to test for them. To use borates to control a pH rise and algae, add borates to between 30 and 50 ppm. Some operators add Borate to produce a silkier feeling water, reduce skin and eye irritation, potentially create a clearer, 'sparkling' water.
	To Lower
	Dilution
	To Raise
	Borax + acid, or Boric Acid
Phosphate	**Notes / Tests**
	Test Using: DR 890 Colorimeter (can be used but procedure is difficult, requires UV digestion) May be used as an algaecide but not usually necessary.
pH Ideal: 7.5 – 7.8 Acceptable: 7.2 – 7.8	**Notes / Test**
	Test Using: 5-in-1 Test Strips
	To Lower
	Borax, Soda Ash (Washing soda), or aeration
	To Raise
	Add muriatic acid (HCl)

Chlorine / Cyanuric Acid (CYA)			
Non-Saltwater Chlorine Generator (Non-SWG) Disinfection			
CYA (stabilizer)	Minimum FC	Target FC	Shock FC
20	2	3	10
30	2	4	12
40	3	5	16
50	4	6	20
60	5	7	24
70	5	8	28
80	6	9	31
90	7	10	35
100	7	12	39
Saltwater Chlorine Generator (SWG) Disinfection			
60	3	4	24
70	3	5	28
80	4	6	30

Salt Water Chlorine Generators (SWG)

One source of free chlorine for disinfection that is increasing in popularity is the use of a saltwater chlorine generator. This inline device electrolyzes the salt in the pool water into free chlorine. When using a SWG, be sure to maintain proper pool water chemistry:

Chemical	Range
FC	3 – 5 ppm
pH	7.5 – 7.8
TA	60 – 80 ppm
CH	50 – 300 ppm for vinyl
	220 – 320 ppm for fiberglass
	250 – 350 ppm for plaster
CYA	70 – 80 ppm
Borates	30 – 50 ppm (Optional)
Salt	200 – 400 ppm above SWG Mfg'r recommended level, typically 2,000 to 3,000 ppm level.

Types of Pool Chlorine

There are a wide variety of products that can be used to provide free chlorine residual in swimming pools. Each has its strengths and weaknesses in a particular pool. The annual cost of chlorine varies widely and is based on both the cost of the chemical used as well as the quantity required.

Swimming Pool Chlorine			
Chemical	Free Chlorine	Cost (%)**	Notes
Trichlor	90%	9% less	Pros: Convenient solid 3" tablet; easy to handle & store Cons: Introduces CYA into pool chemistry which builds up over time and must be reduced; lowers pH
Household Bleach	6.5%	Basis	Pros: Introduces nothing but chlorine and a small amount of salt to the pool chemistry Cons: Bulky
Pool Chlorine (High strength bleach)	12.5%	18% more	Pros: Introduces nothing but chlorine and a small amount of salt to the pool chemistry Cons: Less bulk
Calcium Hypochlorite	73%	26% more	Pros: Convenient power; easy to handle and store Cons: Roughly 1/3 is calcium, which builds up over time and can cause scaling and cloudiness
Dichlor	55.4%	79% more	Pros: Convenient granulated; easy to handle and store; fast dissolving Cons: Introduces CYA into pool chemistry, which can rise quickly and builds up over time; concentration must be reduced to maintain level; lowers pH
Lithium Hypochlorite	35.2%	550 % more	Pros: Convenient powder; easy to use and store; introduces nothing but chlorine to the pool chemistry Cons: Very expensive form of chlorine

** Cost of the chemical to produce the same amount of free available chlorine as compared to using common household bleach.

Shocking the Pool

(a) What is Pool Shocking?

Even with the best of maintenance, the water chemistry of swimming pools can get out of balance, the free chlorine level can be lost, and health/aesthetic problems can occur. Slowly dosing the pool with chlorine is rarely sufficient to correct the problem since increasing organic concentrations (e.g. algae, combined chlorine) is typically faster than the rate the chlorine is metered in the pool. Shocking the pool means applying a high sudden dose of chlorine to oxidize these organics and return the pool to stable water chemistry.

(b) Should I shock the pool?

Shock the pool if any of the following conditions are noted:

1) The combined chlorine level has increased to greater than 0.5 mg/l
2) The free chlorine level in the pool is zero

3) The free chlorine level falls significantly following an event (e.g. heavy rain, large swim party)

(c) How do I shock the pool?

The key to shocking is careful testing for total and free chlorine, and CYA levels. The steps to shock a pool are:

1) Measure the CYA & free chlorine level in the pool
2) Determine the concentration of free chlorine needed to shock the pool from the "Chlorine / CYA Table" above
3) Add enough chlorine to bring the free chlorine concentration to a level slightly above the shock level
4) Repeat at least twice a day, until:
   -- Combined Chlorine (CC = TC minus FC) <0.5mg/l
   -- Less than 1.0 mg/l free chlorine is lost overnight
   -- Water is clear
5) Brush the entire pool once a day
6) Backwash or clean the filter as needed

Calcium Scaling

Calcium scaling is especially important for pools with mineral surfaces (e.g. plaster, pebble, gunite, concrete, quartz, tile, stone). If there is too much calcium in the water, calcium scale can form on the pool and the plumbing, and the water can become cloudy. If there is too little calcium in the water, calcium from the pool surface can dissolve into the water, causing pitting and deterioration, shortening the life of the pool finish.

The risk of calcium scale, clouding, and pitting depends not just on the calcium level, but also on the pH, total alkalinity, and pool temperature. The Calcium Saturation Index (CSI) is a single number showing the overall risk for scaling or pitting. pH has the largest impact on the CSI. If the pH is allowed to rise too high, there is a significant risk of calcium scaling. You can also use the similar, but somewhat less accurate, Langelier Saturation Index (LSI) to calculate acceptable pool saturation.

To prevent scaling and erosion of the pool, the CSI should be between -0.6 and +0.6 at all times

$$CSI = pH + T_f + C_f + A_f - 12.1$$

Where:
T_f = Temperature Index = 0.022 x Water Temperature (°C)
C_f = Calcium Index = 0.4415 x Ln(Calcium Hardness) – 0.0066
A_f = Alkalinity Index = 0.4348 x Ln(Alkalinity) – 0.3951

If the pool fill water has high levels of calcium hardness and high rates of evaporation, calcium hardness levels can rise rapidly. Reducing your total alkalinity and carefully keeping your pH relatively low can manage calcium hardness levels up to 1,200 mg/l. Usually, the most practical way to lower calcium hardness levels is to replace water.

Pool Filters

The heart of a sparkling pool is an effectively operating filter. Pool filters are generally one of three types: Sand, Cartridge filter, or Diatomaceous Earth.

Pool Filtration Systems

Sand Filter

Uses nothing other than sand to filter the water. Pump circulates the pool water through a bed of sand, and the sands naturally jagged texture filters dirt and debris particles down to 20-25 microns. As the sand collects dirt, the filter actually increases its efficiency to trap dirt. When enough dirt collects on top of the sand bed, a noticeable pressure increase is seen on the filter's pressure gauge, indicating that the filter needs to be backwashed.

Pros

- Least expensive filtration system
- Sand is inexpensive to replace
- Requires a full sand change approximately every seven years

Cons

- Backwashing can use a significant amount of water
- Filters particles down to 20 – 25 microns
- May require weekly backwashing during heavy use
- Smaller particles can make their way back into the pool

Cartridge Filter

The most economical of the three filtration systems shown here. Cartridge filters are readily available and affordable. This filter type uses a replaceable pleated paper cartridge filter. Water moves through the fabric and dirt particles are trapped on the surface. Cleaning can be as simple as taking the filter cartridges out of the canister and hosing them off.

Pros

- Clean by rinsing with a garden hose
- Filters down to 5-10 microns
- Easy maintenance
- Runs at lower pressure, putting less back pressure on the pump

Cons

- Long-lasting filters are available, but a bit more expensive
- Will require full replacement of the cartridges more often than sand and D.E.

Diatomaceous Earth (D.E.) Filters

A D.E. filter will get the water the cleanest of the three, but that cleanliness comes at a price. These are the most expensive of the filtration options. Their outstanding filtration abilities and somewhat delicate maintenance needs make these most appropriate for commercial applications. D.E. filters use fossilized diatoms (plankton skeletons) to coat a grid that looks similar to a cartridge filter. The grids are packed with D.E. Powder that catches particles as small as 3 microns, resulting in sparkling water. As with the sand filter, the D.E. filter must be backwashed when the pressure drop the filter increases, indicating a soil load on the grids. All D.E. filters should have a thorough cleaning once a year.

Pros

- Provides the best filtration of the three choices
- D.E. powder can be added to the grids through the pool's skimmer
- Filters particles down to 3-5 microns

Cons

- Initial start-up cost is high
- Backwashing can use a significant amount of water
- Maintenance is a bit higher than the other systems

Chemical Safe Handling

Swimming Pools are chemical factories. Maintenance personnel must use a variety of chemicals daily to maintain proper water quality in the pools. Among the most dangerous of these chemicals is chlorine. Regardless of the form of the chlorine that is being added to the pool to disinfect and control algal growth, remember that ALL CHLORINE IS DANGEROUS. Handle with great care.

Remember:

(a) Read the chemical container to assure that you have the right chemical – know what you are using

(b) Read the directions carefully and follow the manufacturer guidance exactly

(c) Read the Manufacturer Safety Data Sheet (MSDS) before handling the chemical and have it handy for reference if needed

(d) Never mix chemicals unless specifically directed by the manufacturer

References

(a) Pool School (www.troublefreepool.com) an excellent site for learning about pool operations and maintenance. Also have a community blog to get questions answered by other users and some good tools.

(b) "Swimming Pool Operations & Maintenance Guide", A/FBO/OPS/FAC, DoS Publication 9858, March 1992

(c) "Swimming Pool Operation & Maintenance", TM 5-662, Headquarters, Department of the Army, 28 Feb 1986. A bit dated, but a good reference for overall pool operations.

(d) www.healthypools.org is an interesting site for comparing your swimming pool pH and Free Chlorine levels with others in your area.