Pool Operator Prep Manual

FOR THOSE INDIVIDUALS PLANNING TO CERTIFY

Revised by Tropical Aquatics for Florida Pool Operator Certification

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You may also wish to down-load the
Math Tutorial for Pool Certification at
http://www.thepoolclass.com/support/math/

For more intense preparation, check out the
Support library at
http://www.thepoolclass.com/support/library/

FORMULAS FOR POOL CALCULATIONS

L = length **W** = width **V** = volume **D** = depth

r = radius (half of the diameter of a circle)

π = (pi) 3.14 (a factor used in calculations with circles)

ppm = parts per million, or in Florida's code, mg/L an equivalent number

SURFACE AREA

Rectangular pool = L x W

Circular pool = r^2 x π or r x r x π

Right triangle = (L x W) ÷ 2

AVERAGE DEPTH (D_{Avg})

For constant slope: [D (shallow) + D (deep)] ÷ 2 = AVERAGE DEPTH

Note: For multi-depth pools calculate the volume in sections of constant slope and add them together.

CUBIC FEET OF VOLUME (surface area times average depth)

Rectangular pool V = L x W x $D_{Avg.}$

Circular pool V = r^2 x π x $D_{Avg.}$

POOL GALLONAGE IN CUBIC FEET (cubic foot of water = 7.5 gallons)

Rectangular pool gallons = L x W x D_{Avg} x 7.5

Circular pool gallons = r^2 x π x D_{Avg} x 7.5

FLOW RATE/TURNOVER RATES

SPAS: Required turnover every 30 minutes therefore required flow rate is:
Gallons ÷ 30 minutes = minimum (min) flow rate in gallons per minute (GPM)

POOLS: Required turnover at least every 6 hours (6 x 60 min = 360 min)
Gallons ÷ 360 minutes = min flow rate in GPM

Health Club Pools (less than 1,000 square feet):
Required turnover at least every 3 hours (3 x 60 min = 180 min)
Gallons ÷ 180 minutes = min flow rate in GPM

CHEMICAL ADJUSTMENT CALCULATIONS

You will need the dosage information for the chemical, i.e. the standard amount of a chemical needed to adjust a standard amount of water. This information is on the product label, or in the test kit guidebooks. The information is usually listed, for example, as “2 oz per 10,000 gallons of water to raise pH 1 ppm.” This amount needs to be converted (or calculated) to be specific for YOUR pool.

Except when doing breakpoint chlorination, chemical additions should be broken down into smaller amounts. The calculated amounts are approximate, and you will want to “sneak up” on the water chemistry value you are trying to reach. Add 1/3 of the amount calculated, allow to mix, retest, then add another 1/3, and so on. Better to work up to the right reading than to over-shoot the mark and have to adjust AGAIN back down.

You want to calculate how much chemical added to the volume of water in you pool will change the chemical value the desired amount.

NEEDED INFORMATION ABOUT YOUR POOL:

POOL VOLUME: amount of water in your pool

DESIRED CHANGE: amount of change (in ppm) that needs to take place in your pool, called **$\text{Change}_{\text{ppm}}$**

CHEMICAL DOSAGE INFORMATION: Taken from the chemical label or a table, called **$\text{Label}_{\text{ppm}}$**

AMOUNT OF CHEMICAL (**$\text{Label}_{\text{amt}}$**)= amount of chemical added to a:

GIVEN WATER VOLUME (LABEL VOLUME) produces a;

DESIRED CHANGE (**$\text{Change}_{\text{ppm}}$**) to the pool chemical parameters

So read the above 3 items as: 1.5 pounds of sodium bicarbonate (**$\text{Label}_{\text{amt}}$**) per 10,000 gallons (**LABEL VOLUME**) increase the Total Alkalinity 10 ppm (**$\text{Label}_{\text{ppm}}$**).

THE FORMULA (Terms are defined above):

SIZE FACTOR = ACTUAL POOL VOLUME ÷ LABEL VOLUME

CHANGE FACTOR = **$\text{Change}_{\text{ppm}}$ ÷ $\text{Label}_{\text{ppm}}$**

CHEMICAL DOSAGE FOR YOUR POOL =

SIZE FACTOR x CHANGE FACTOR x AMOUNT OF CHEMICAL

Example 14,000 gallon pool, increase total alkalinity by 20 ppm

Chemical Dosage = [14,000 gal ÷ 10,000 gal] x [20ppm ÷ 10ppm] x 1.5 lbs. Sodium Bicarb.

Chemical Dosage = 1.4 (Size Factor) x 2 (Change Factor) x 1.5 lbs = 4.2 lbs of sodium bicarbonate is needed in a 14,000 gal. pool to raise the Total Alkalinity 20 ppm.

WATER CHEMISTRY

DEFINITIONS

Sanitizer: A chemical product that will sanitize or disinfect water by destroying living organisms, bacteria and viruses in sufficient numbers (99.9 %) to prevent disease.

Sanitization: Sanitization or disinfection is the process of destroying living organizms, bacteria and viruses in sufficient numbers to prevent disease. Typically we measure the processes effectiveness by looking for a 3-log (99.9 %) or 4-log (99.99 %) reduction in the number of organisms. Sanitization does not necessarily mean the destruction of all organisms.

Oxidation: Oxidation is a burning out process to convert complex organic molecules to simple compounds and eventually to a harmless gas that can escape the pool (CO_2, elemental nitrogen and others). Dust, algae, human wastes, leaves and other materials, are examples of organic and nitrogen contaminants.

Halogen: Halogen is the term used to refer to any of five elements in group VII of the periodic chart.

Of the five halogens, we use chlorine and bromine for pool treatment.

Free Available Chlorine (FAC): FAC is the chlorine residual that does the sanitization and oxidation. The FAC is tested using DPD #1 and measures HOCl and OCl^-. HOCl is the active chlorine, and OCl^- is an inactive form of FAC. The ratio of HOCl / OCl^- is very dependent of the pH. At a pH of 7.2, about 2/3 of the FAC formed is in the form of HOCl. At a pH of 8.0, only about 1/3 of the FAC is HOCl with the rest as inactive OCl^-.

HALOGENS			
Group VII	Molecular Form	Physical State	Characteristics
Fluorine	F_2	Gas	Extremely reactive, Dangerous to handle.
Chlorine	Cl	Gas	Gas form dangerous, Good oxidizer, Most commonly used.
Bromine	Br	Liquid	2.25x heavier than Chlorine, Fair oxidizer.
Iodine	I_2	Solid	Stains, Difficult to handle, Poor oxidizer.
Astatine	At	Solid	Radioactive. Not used in pools

Combined Available Chlorine (CAC): CAC is the chlorine residual that is combined with nitrogen products such as ammonia (NH_3). The CAC is usually calculated by subtracting the FAC from the TAC. Ideally there should be no CAC in the water, or maintained as low as possible. It is very irritating at levels as low as 0.5 ppm. It is a very stable compound, but can be removed from the water by doing a “Breakpoint Chlorination”

Total Available Chlorine (TAC): TAC is the measure of FAC + CAC. It is measured by DPD #1 and DPD #3. The CAC level can be determined by subtracting the FAC (DPD #1) reading from the TAC (DPD #1 & DPD #3) reading.

Breakpoint Chlorination: Breakpoint chlorination is the process of adding sufficient chlorine to oxidize any combined chlorine and other nitrogen wastes to elemental nitrogen which gases off.

Parts per million (ppm): ppm is a weight / weight measure equivalent to milligrams per liter (mg/l). It is equivalent to 1 pound of chemical in 1,000,000 pounds (approximately 120,000 gallons of water).

CHLORINE SANITIZERS

Inorganic Chlorine Products

Chlorine Gas (Cl_2)(100% available Chorine): Chlorine gas is the most concentrated form of chlorine available. It is cheap and very effective. Unfortunately, Cl gas has been regulated almost entirely out of use for swimming pool sanitization. Chlorine gas is now a restricted pesticide, requiring special training and certification, special safety precautions and equipment, and it falls under the oversight of many national, state, and local jurisdictions. If you presently use it, start working to switch to another sanitizer.

Sodium Hypochlorite (NaOCl) (Liquid chlorine, bleach): Usually 10-12% available chlorine, bleach is 5.25 % available chlorine. Fairly cheap source of Cl, but will degrade over time and if stored improperly. Store in a cool, dark place. Household bleach and be used in an emergency (Do not use scented bleaches). Household bleach is half the strength and has more solids and possibly metals in it.

Calcium Hypochlorite ($Ca(OCl)_2$)(65 % available chlorine): Often referred to as “cal-hypo” or.“HTH.” Originally sold as a granulated powder for use as a shock, or dissolved and decanted (it forms a lot of sludge when dissolved., clear liquid has the Cl.) as a liquid source of chlorine. In recent years it has also been manufactured in a “tablet” and “puck” form for use in erosion feeders designed specifically to feed cal. hypo. **DO NOT USE CALCIUM HYPOCHLORITE IN A TRICHLOR OR BROMINE EROSION FEEDER. IT WILL CAUSE AN EXPLOSION.** Some manufacturers are now placing blue specks in the calcium hypochlorite tabs and pucks.

Cal-hypo stores well in a cool dry location. It can be a significant fire hazard if it gets wet, or is contaminated with other products. Do not dispose of this product in the trash. Use it in the pool, rinse and clean empty containers before placing out for trash pickup. Container disposal has been a large concern for solid waste haulers due to the fire hazard as well as toxic gas production. There may be new disposal regulations developed in the near future by the solid waste regulatory entities.

Lithium Hypochlorite (LiOCl)(35 % available chlorine): Available in a granulated powder product. Used for shocking. Product is clean dissolving and easy to use. Not used much in the pool industry because of the high cost. It can also be a fire hazard if stored improperly or contaminated.

Organic Chlorine Products

Trichlor (Trichloro-s-triazine Trione, Trichloroisocyanuric acid)(90 % Avail. Cl): Also known as “stabilized chlorine.” And “erosion chlorine.” Slow dissolving product manufactured in sticks, tablets and pucks. Made to use in a “trichlor” erosion feeder. Product comes with three Chlorine atoms attached to cyanuric acid (CYA). CYA is used as a “stabilizer “ to protect the Cl from UV light degradation. CYA does not protect Cl indoors, in fact it can become a nuisance and interfere with disinfection and oxidation at higher levels. Trichlor is fairly expensive.

Dichlor (Sodium Dichloro-s-triazine Trione, Sodium Dichloroisocyanuric acid) (62% avail. Cl): Dichlor has been used mainly in the laundry industry as “dry bleach.” It’s use in swimming pools is mainly as a shock. It is fast dissolving, but adds considerable CYA to the pool, which may be undesirable. Can be a fire and Cl gas-producing hazard if wetted or contaminated.

SANITIZING WITH CHLORINE

Chlorine is the most popular and efficient pool sanitizer available. If it is maintained at the required levels and the proper pH is maintained, it will kill most organisms in less than a minute. It is present in all of the sanitizing systems approved by the state for use in public pools and spas.

Whichever form of chlorine you choose to use, the reaction of the chlorine product with water will produce **“hypochlorous acid” (HOCl)**, and other by products. HOCl is the active sanitizer and oxidizer. You test HOCl as **Free Available Chlorine (FAC)**, using DPD #1 in your test kit and a color comparator, or your DPD powder and using the titrating solution if your have that type of test.

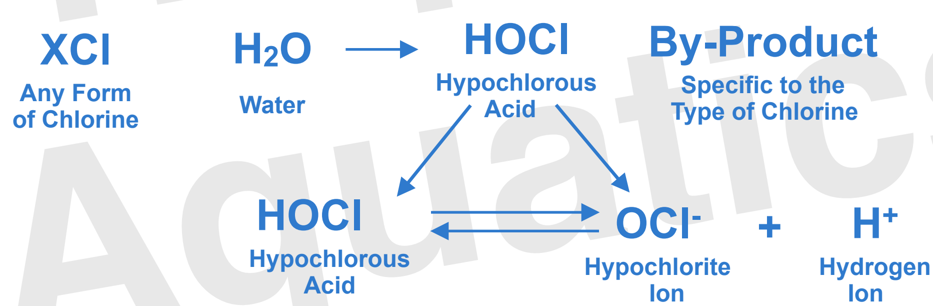
Sanitizing the Water

The HOCl will react with organisms in the water and kill them. We are particularly interested in killing those that could cause swimmer illness. Typically, little of the chlorine in the pool is needed to kill the microorganisms. With the exception of some protozoan organisms (Cryptosporidium, Giardia, Cyclospora), most organisms will be killed by very low levels of chlorine in very short periods of time (seconds to 1-2 minutes).

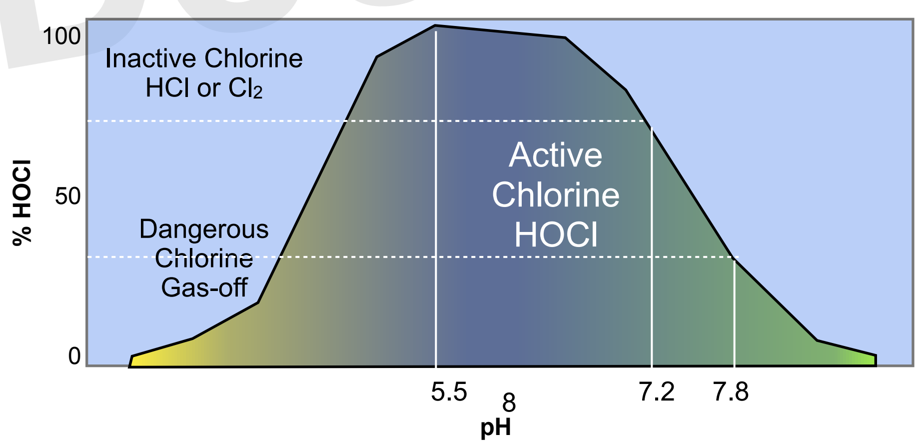
HOCl will react with the bacteria, viruses, protozoa, algae in the water and will kill or eliminate them. It also reacts with the oils and greases, leaves, dead bacteria, skin particles and other organic contaminants, to “oxidize” (breakdown or burn up the organic materials) and eliminate them from the water.

The oxidation process can be compared to burning a pile of leaves. They don’t burn quickly and create lots of smoke. If we put a box over the pile of leaves, the box will fill with smoke, and because the fire cannot get fresh air, the fire will go out.

A similar burning process in the swimming pool, creating a gas-off product (nitrogen trichloride – a form of combined chlorine or chloramine) that is irritating like smoke causing red burning eyes, coughing, and nose and throat irritation. At most outdoor pools the smoke is blown



away and with lots of fresh air, the oxidation can continue, so we find few problems with chloramines or combined chlorine. Indoor pools, like the pile of leaves with the box over the top, trap the “smoke” causing swimmer discomfort, and the lack of fresh air causes the oxidation to stop before everything is oxidized. Many times it is almost impossible to get rid of all the combined chlorine at an indoor pool. It is very important to get lots of fresh outside air into the pool area by opening windows and doors and adding fans to blow across the water.



% of HOCl Formed at Various pH Values

CHLORINE PRODUCTS
AND THEIR REACTIONS IN WATER

The amount of hypochlorous acid (HOCl) formed in each reaction is dependent on the pH of the water. Low pH will form more HCl and Cl_2 gas, pH at 5.5 forms almost totally HOCl and as the pH increases lower amounts of HOCl are formed and increasing amounts of OCl^- are formed. OCl^- is inactive as a disinfectant.

Combined Chlorine (Chloramines)

Combined chlorine is the reaction of “hypochlorous acid” (HOCl) with nitrogen containing compounds, particularly ammonia (NH3). Depending on the chlorine concentration, the pH and the temperature the hypochlorous acid / ammonia mixture will form one of three compounds.

Monochloramine NH_2Cl
Dichloramine $NHCl_2$
Trichloramine NCl_3 (Also known as Nitrogen trichloride)

With enough free chlorine and adequate ventilation to blow away the breakdown products that gas off the pool, the chlorine will break down the ammonia products until nitrogen is all that is left, which gases off the pool.

Unfortunately the process seldom goes perfectly. Often we get a lot of trichloramine (NCl_3) which is an oily substance that volatilizes out of the water into the air. Nitrogen trichloride is the cause of most of that “swimming pool” smell. It can be highly irritating and is the cause of the lung, eye and throat irritation people experience in poorly ventilated indoor pools.

To combat the buildup of chloramines the operator can use chlorine to breakpoint chlorinate the pool, use a non-chlorine oxidizer (potassium or sodium monopersulfate), use ozone, install medium-pressure UV light treatment, or increase the ventilation and air blowing across the pool. The last three treatments are costly methods of controlling chloramines, and are only practical on larger pools, although most pools can increase ventilation for short periods by using fans and opening outside doors or windows.

Breakpoint Chlorination:

Breakpoint chlorination is a calculated process. The amount of combined chlorine (chloramines) in the pool must be known. If we take the amount of combined chlorine in ppm and multiply that by 10, we can determine how much total free chlorine must be in the pool to reach breakpoint. You subtract your current free chlorine amount from this new overall free chlorine to determine the new chlorine amount to be added.
Example: You test the pool and find 2 ppm combined chlorine. You have 1.5 ppm free:
2 ppm x 10 = 20 ppm of overall chlorine that must be in the pool to reach breakpoint.
20 ppm - 1.5 ppm = 18.5 ppm of new chlorine to be added.

TO ACHIEVE BREAKPOINT YOU MUST ADD AN AMOUNT OF NEW FREE CHLORINE THAT WILL ACHIEVE 10 TIMES THE COMBINED CHLORINE LEVEL

WATER BALANCE

“Water Balance” is the process of maintaining the water in a state that is neither non-scaling nor corrosive. It is comfortable for the swimmers and easy on the pool equipment and pool surfaces.

To achieve this, the pool must be maintained at the “calcium saturation level.” This means that the amount of calcium dissolved in the water is the maximum amount the water will hold without any precipitating out. We can calculate this using the “Langelier Index” shown later in this document.

You can think of water that is not saturated with calcium as “hungry,” it will look for something to satisfy its hunger causing corrosion of the pool surfaces and eating away at the metal components of the recirculation system. If it is “overfed,” the excess calcium is deposited as scale on surfaces and can cause cloudy water as the calcium comes out of solution.

To determine “calcium saturation,” or “water balance,” we look at the relation of 5 different measurements of the water. These factors are:

- **pH**
- **Total Alkalinity (TA)**
- **Calcium Hardness (CH)**
- **Temperature of the Water (°F)**
- **Total Dissolved Solids (TDS)**

pH

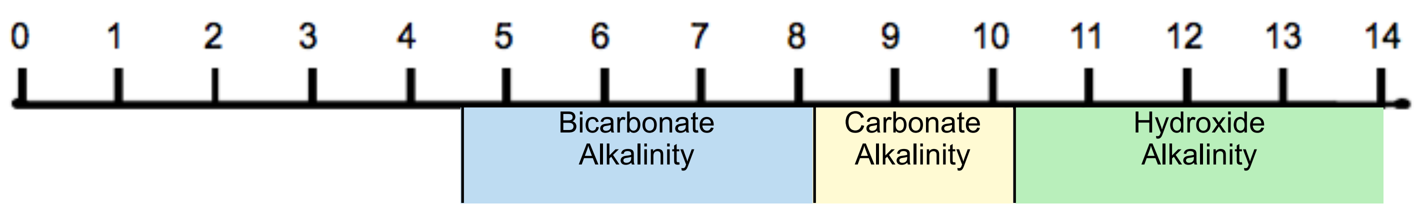
pH is technically the “negative logarithm of the hydrogen ion (H^+) concentration.” In simpler terms it is how “acidic” or “basic” a solution is. It is based on a scale from 0 to 14 where the lower the number the more acidic the solution.

Total Alkalinity (TA)

Total alkalinity is the measure of how stable the pH is. It measures the pool water’s buffering capacity to resist pH changes. Without control of the total alkalinity, the pH will rise and fall abruptly. The ability to resist this change in pH is due to the presence of bicarbonate and carbonate ions and other compounds.

In general, total alkalinity should be kept between 80 ppm and 140 ppm but this will vary from region to region. The ideal reading for alkalinity will vary due to three variables: (1) type of pool, (2) type of sanitizer, and (3) type of shock.

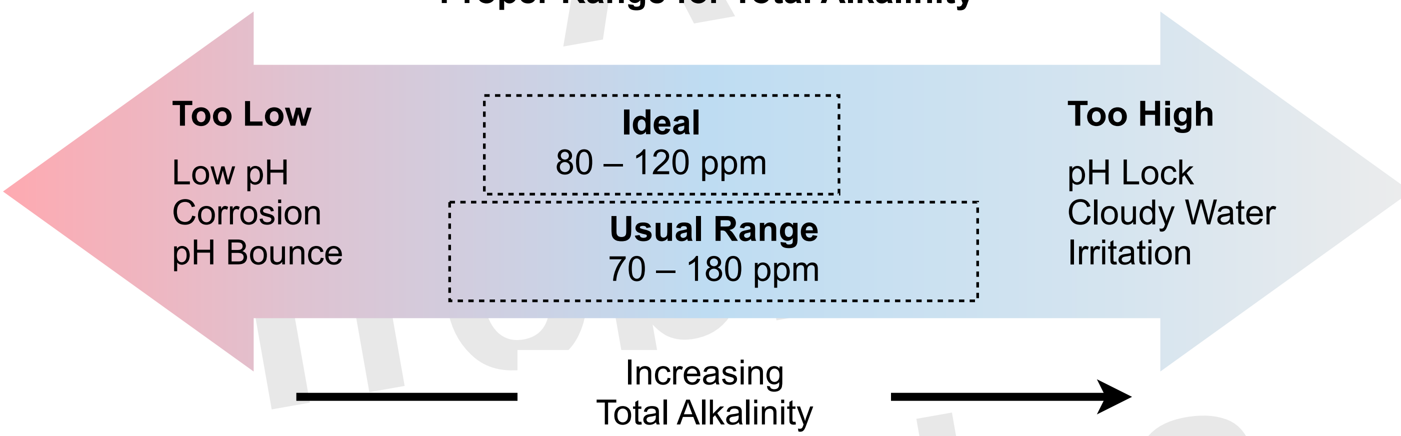
When alkalinity is either too high or too low, water acts much like that with a low pH or high pH level.



A low total alkalinity makes it difficult to maintain a desired pH and can lead to corrosive water, which can damage equipment. Green water can also be another symptom of low total alkalinity. To increase the alkalinity level, add sodium bicarbonate, typically packaged as “Alkalinity Increaser”, “Alkalinity Up”, or “Alkalinity Plus”.

High levels of total alkalinity can cause the pH to “get stuck” and is difficult to change. High Total alkalinity can also cause cloudy water and scale formation. To decrease the alkalinity level, sodium bisulfate or muriatic acid can be added to the pool water – these are the same chemicals used to lower pH. Always read the instructions on the label before adding any type of chemical, as manufacturers will recommend varying amounts to add per 10,000 gallons of water as well as the specific procedures.

Proper Range for Total Alkalinity



Calcium Hardness

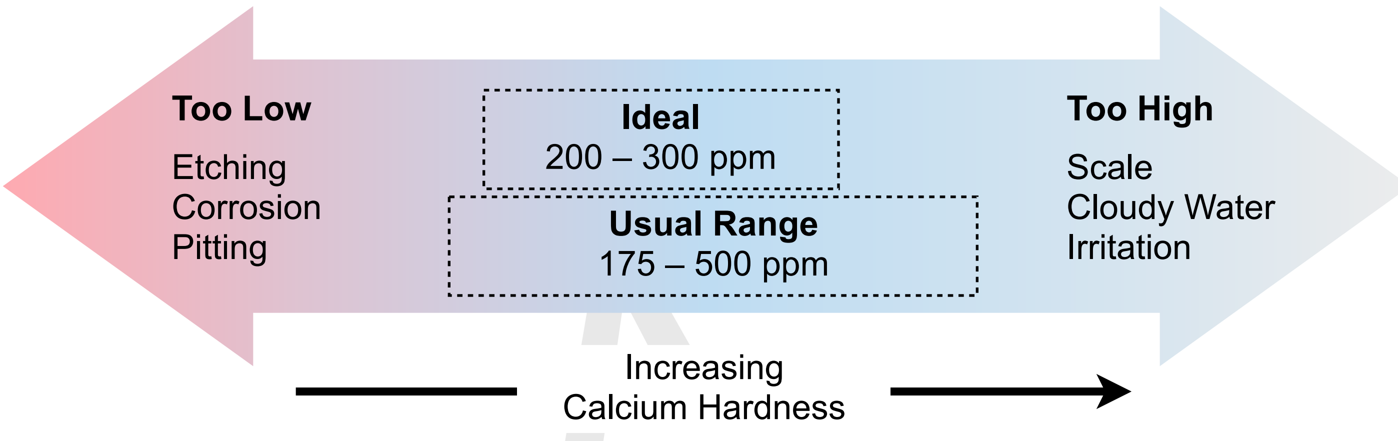
Calcium hardness testing is a measure of the hardness minerals in the water. There are several, but the most important is calcium, and hardness, when tested with your pool test kit, is reported in equivalence to $CaCO_3$.

Soft water is good for washing or when soap is used, as the soap does not form a sticky layer of soap & minerals on the water’s surface, hence “hard water.” In soft water the soap foams well and clothes usually stay whiter.

In pools, we are concerned with maintaining the pool surfaces and equipment. We are attempting to maintain water that is saturated with calcium to prevent the corrosion of the surfaces and equipment. However, we don’t want so much calcium that is will not all stay dissolved in the water, “scaling” out on pool surfaces and inside equipment and piping. Scaling can make the surfaces rough and actually plug piping with calcium scale. Watch your pool heater.

To maintain calcium saturation we must consider the calcium level as well as pH, total alkalinity, temperature and total dissolved solids.

Proper Range for Calcium Hardness



Total Dissolved Solids (TDS)

Total dissolved solids (TDS) are a measure of all the stuff dissolved in the water that would be left in a sample if the water was removed. Sort of like the stuff left when a teapot has been reheated and the water evaporated.

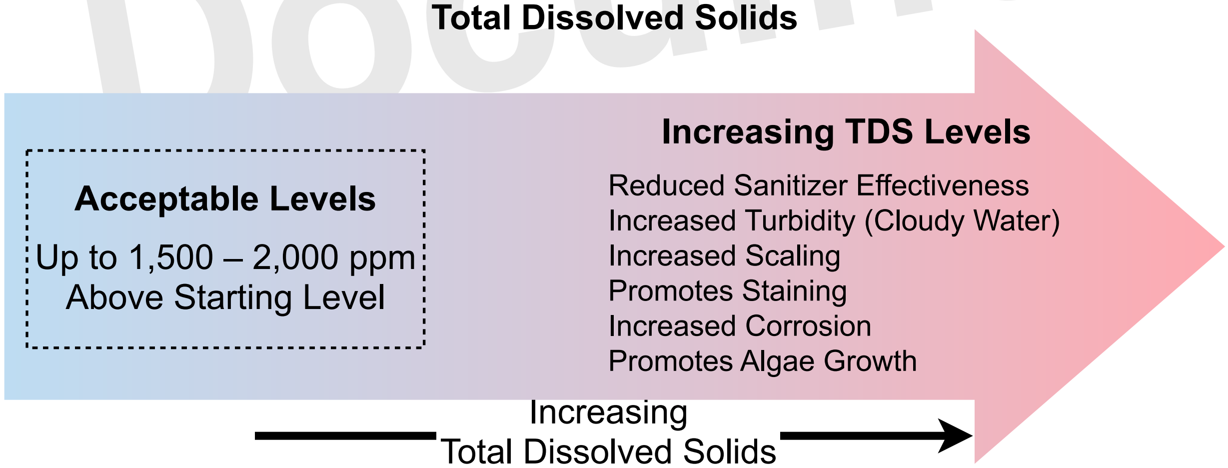
The solids are made up of minerals, organic materials, oils, and other material in the water. Most anything that is added to the water contributes to the total dissolved solids, especially the swimmers.

Potable water usually has about 100 ppm (TDS). As the water ages the TDS climbs until we can think of the water as crowded with dissolved material. This condition makes it hard to disinfect and control the water quality in the pool. Usually we will drain the pool and replace the water when the TDS becomes this high by either draining all the water, or diluting the pool with repeated partial drain and refills.

With salt water pools, the pools start off with TDS levels close to 3500 ppm. We would begin to dilute and drain these pools once the TDS climbed about 1500 ppm over what it was to begin with.

TDS is tested by using a conductivity meter. Pure distilled or completely deionized water will not conduct electricity. As minerals and things are dissolved in the water the water will conduct electricity better and better. The conductivity meter will measure this and relate it to the TDS levels.

Total Dissolved Solids



Temperature

Temperature is a real concern when dealing with calcium saturation because calcium carbonate, the most common form of calcium, is more soluble in colder water. This is contrary to what we find with most other materials we can dissolve in water.

The concern is the warmer the water the lower the calcium hardness needs to be to be at saturation, so spas do not need as high a level of calcium. The other concern is where the pool is winterized during the colder weather. If the calcium isn't adjusted for the cold water temperatures, the pool basin can suffer from the corrosive water

For most pool operators, there is little control over the temperature. The public likes swimming in water of a certain temperature depending on the activity. We cannot cater to each group without greatly increasing the heating costs. Most operators find a median temperature and leave it there when the pool is open for swimming.

Common temperature preferences:

Polar Bear Club – usually 45 – 60° F

Serious Lap Swimmers – about 78°F

Recreational Swimmers – about 82 – 84°F

Classes (children) – about 86 – 90°F

Older Exercisers – about 86 – 95°F

Spa Users – (Hotter is better)
Do not exceed 104°F Recommend 102°F

Florida's Code only regulates spa temperatures. At this time the rules allow a maximum 104°F. Over the years we have found that this temperature can be harmful to some people. It is our strong recommendation that spas be maintained at no more than 102°F.

The lower temperature is much safer for pregnant women, older users, persons using the spa while intoxicated (not recommended) and for small children (not recommended). Studies have shown that most people cannot sit in a 104°F spa for more than 15 minutes without risking the chance of overheating. Most people can sit in a spa at 102°F for much longer periods of time without harmful health effects. **Always have permission from your doctor before using a warm water amenity.**

THE LANGELIER INDEX

The Langelier index is one of several methods of calculating calcium saturation in your pool. Your pool test kit has a device to also test for calcium saturation. One of the other popular methods of calculating the saturation is the “Rysnar Index”

All the indexes use the pH, total alkalinity, calcium hardness, temperature and total dissolved solid levels in your pool. The relation of these allows us to determine the calcium saturation.

The Langelier index, used here, is one the health departments will most often use. The calculation uses the pH of the water as is, and adds factors off the table below for total alkalinity, calcium hardness and temperature. Total dissolved solids do not change the calculation much, and are often used as a constant of **-12.1**. If the TDS is over 1000 ppm the constant can be changed to **-12.2**.

The formula for calculating the calcium saturations is:

Saturation Index = pH + TF + CF + AF – 12.1

pH = pH as tested | **CF = Calcium Factor**

TF = Temperature Factor | **AF = Alkalinity Factor**

Factors Chart

Temperature		Calcium Hardness expressed as CaCO		Total Carbonate Alkalinity	
°F	TF	ppm	CF	ppm	AF
32	0	25	1	25	1.4
37	0.1	50	1.3	50	1.7
46	0.2	75	1.5	75	1.9
53	0.3	100	1.6	100	20
60	0.4	125	1.7	125	2.1
66	0.5	150	1.8	150	2.2
76	0.6	200	1.9	200	2.3
84	0.7	250	2	250	2.4
94	0.8	300	2.1	300	2.5
104	0.9	400	2.2	400	2.6
		800	2.5	800	2.9

Values between +0.5 and -0.5 are considered balanced.

Negative values are corrosive.

Positive values are scale forming

CHEMICAL DOSAGES

Using the formula found on page 4:
CHEMICAL DOSAGE FOR YOUR POOL = SIZE FACTOR x CHANGE FACTOR x AMOUNT OF CHEMICAL

You can use the accompanying dosages to figure out how much chemical you will need to make changes to your water chemistry. Remember, “breakpoint chlorination” requires that the entire calculated amount be added at once. All other chemical parameters should be adjusted slowly by breaking up the dosage calculated into smaller additions to add to the pool, allowing mixing between additions.

Dosages to Treat 10,000 Gallons				
Chemical	**Desired Change**			**Effect on pH**
Increase Chlorine	**1 ppm**	**5 ppm**	**10 ppm**	
Chlorine Gas	1.3 oz.	6.7 oz.	13 oz.	↓↓
Calcium Hypochlorite (67%)	2 oz.	10 oz.	1.3 lbs.	↑↑
Sodium Hypochlorite (12%)	10.7 fl.oz.	1.7 qts.	3.3 qts.	↑↑
Lithium Hypochlorite	3.8 oz.	1.2 ibs.	2.4 lbs.	↑
DiChlor (62%)	2.1 oz.	10.75 oz.	1.3 lbs.	↓
DiChlor (56%)	2.4 oz.	12 oz.	1.4 lbs.	↓
TriChlor	1.5 oz.	7.5 oz.	14 oz.	↓↓
Increase Total Alkalinity	**10 ppm**	**30 ppm**	**50 ppm**	
Sodium Bicarbonate	1.4 lbs.	4.2 lbs.	7.0 lbs.	↑
Sodium Carbonate	14 oz.	2.6 lbs.	4.4 lbs.	↑↑
Sodium Sesquicarbonate	1.25 lbs.	3.75 lbs.	6.25 lbs.	↑
Decrease Total Alkalinity	**10 ppm**	**30 ppm**	**50 ppm**	
Muriatic Acid (31.4%)	26 fl.oz.	2.4 qts.	1 gal.	↓↓
Sodium Bisulfate	2.1 lbs.	6.4 lbs.	10.5 lbs.	↓↓
Increase Calcium Hardness	**10 ppm**	**30 ppm**	**50 ppm**	
Calcium Chloride (100%)	0.9 lbs.	2.8 lbs.	4.6 lbs.	↑
Calcium Chloride (77%)	1.2 ibs.	3.6 lbs.	6.0 lbs.	→
Increase Stabilizer	**10 ppm**	**30 ppm**	**50 ppm**	
Cyanuric Acid	13 oz.	2.5 lbs.	4.1 lbs.	↓
Neutralize Chlorine	**1 ppm**	**5 ppm**	**10 ppm**	
Sodium Thiosulfate	2.6 oz.	13 oz.	26 oz.	→
Sodium Sulfite	2.4 oz.	12 oz.	1.5 lbs.	→

DISEASES AND SANITATION

There are a variety of diseases that are of concern in swimming pools and spas. Many of the more serious are gastrointestinal in nature causing diarrhea, vomiting, abdominal pain, fever and malaise. Diseases can also be spread by, and infect the nose, eyes, ears, genitals, skin and wounds.

Area under the swimsuit has an excessive number of organisms and organic material to shed in the pool if without adequate bathing before entering the pool

Intestinal Diseases – Shigellosis, E. Coli, Giardiasis, Cryposporidiosis, and others can be spread by swallowing the disease organisms after they have been excreted by the carrier. Most microorganisms are very susceptible to chlorine disinfection, though some have shown remarkable resistance. Most important is to avoid swimming if you have had diarrhea within the last two weeks. Thorough showering can also help.

Up to 36,000 Microorganisms with clearing the nose

Respiratory Diseases – Colds, Strep throat, Pseudomonas, and Legionellosis can be readily transmitted by persons having these diseases. Prolonged contact with the water can remove protective coatings in the respiratory tract making a person more susceptible to infection.

Hands may have 1/2 to 5 million organisms shed with one washing

Eye, ear, and skin infections – Athlete's foot, granuloma, impetigo and pinkeye are some of the more common infections that can be transmitted from one person to another. In addition to the pool water, transmission can occur because of dirty floors, seats, counters swim suits, towels, rough surfaces and combs.

From 100 million to 1 billion organisms from 1 gram of saliva

Pseudomonas Auriginosa – is one of the most common skin infections with transmission usually occurring in spas. The organism can be easily passed between bathers because of the large amount of chlorine used up when several people are in a small volume of water like a spa. Showering is a good preventative measure for preventing transmission. Pseudomonas can causes serious respiratory eye, and ear infections.

Aids and Herpes Viruses – These viruses are not usually associated with transmission in public pools during normal swimming activities. They are sexually transmitted.

Boils and infections Source of highly infective disease organisms

Perspiration (active swimmer) 2 pints per hour.

FILTRATION

Definitions

Biologically Clean water: Water that is free from harmful bacteria.

Physically Clean Water: Water that is free of particulate matter; suspended particles which make the water turbid (cloudy).

Flowrate / Recirculation Rate: The rate of water- flow through the recirculation system, usually expressed in gallons per minute (GPM).

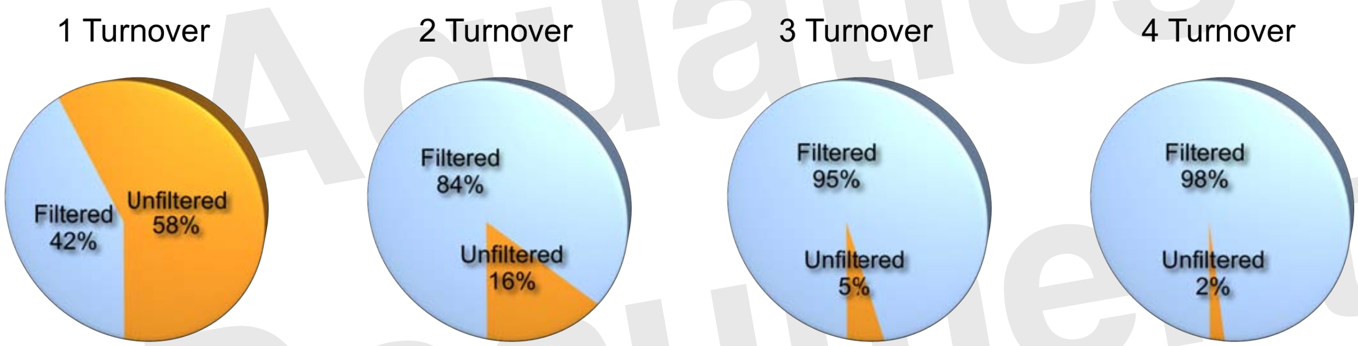
Turnover Time: The amount of time required to move a volume of water, equivalent to the pool volume, through the recirculation system.

> **Pools**: Turnover time (hrs.) = Pool volume (gal.)/(60 X flowrate (GPM))
>
> **Spas:** Turnover time (min.) = Spa volume (gal.)/ flowrate (GPM)

From page 3 and expressed in Florida's Administrative Code 64E-9:

> **SPAS:** Required turnover every 30 minutes
>
> **POOLS:** Required turnover at least every 6 hours
>
> **Health Club Pools (less than 1,000 square feet):**

AMOUNT OF WATER FILTERED



> Required turnover at least every 3 hours

Filter Operational Considerations			
	Sand (High Rate)	**Diatomaceous Earth**	**Cartridge**
Initial Cost	Medium	High	Low
Media Replacement Cost	Low - Only every 5 to 15 years	Acceptable	Very High
Clarity	Acceptable 25 to 100 Microns	Excellent 4 to 6 Microns	Very Good 10 to 25 Microns
Cleaning Effort (Time)	Little	Medium	Very Labor Intensive
Flowrate (GPM/sq.ft.)	15 to 20	2	0.375

SAND FILTRATION

Sand filtration is the oldest of the different types of filtration. It has developed through several stages and types of filters, over thousands of years.

Gravity sand: Is the earliest type of sand filter. The sand was deposited in a tank in graduated sizes from fine sand, at the top, to pea gravel to larger sizes of gravel, at the bottom. Filtration occurred as water was introduced on top of the sand and allowed to flow through the sand with the aid of gravity. Flow through the sand was about a maximum of 1.5 GPM/ sq. ft. of filter surface area. The filter housings were very large.

Rapid rate sand: Flow throughput was fast compared to the gravity. The flow is established by mechanical means and the water is pulled or pushed through the sand and gravel. At 2 – 4 GPM / sq. ft.. this is much faster and requires less than half the surface area needed for the gravity sand. The filter housings are still quite large. Filtration occurs at the top surface of the fine sand.

High rate sand: Was developed during WWII when clean drinking water needed to be provided to the troops but large tanks were impractical to move around. Today's high rate sand filter has a sand bed made up of typically #20 silica filter sand. This sand has jagged edges, so does not pack down tightly allowing the water to run through easily, but trapping the dirt. These filters use about the top 6 inches of the sand depth for filtration. Today all sand filters now days are high rate sand filters. Flow rates vary from 15 – 20 GPM / sq.ft. of filter surface area.

A Modern High-Rate Sand Filter

Backwashing: Is the process of cleaning a sand filter. The water flow is reversed through the filter at a rate that exceeds the flowrate of 12 -15 GPM / sq.ft. of filter surface. This flow is enough to lift the sand particles and allow the dirt to be washed out, but not so much the sand is washed out as well.

How long will the sand last? There are still some gravity sand and rapid rate sand filters still using their original sand after many, many years. However, the high rate sand filter seems to require occasional sand replacement. Usually the sand becomes coated with oils and greases that trap dirt onto the sand particle. If the sand is thoroughly cleaned routinely, the sand can last for as much as 15 years. As a usual rule though, most pools need to change their sand about every 5 years with regular care.

DIATOMACEOUS EARTH (D.E.)

Diatomaceous earth filtration is a type a filtration with "replaceable media," as compared to "permanent media" that is not replace like sand and cartridge filtration. With DE filtration, once the reaches minimum, it is necessary to backwash or clean the filter and remove all the dirty DE. The media is replaced with clean DE, which is coated onto the filter elements or septa, and the filter run begins again.

Diatomaceous earth is the silica-based skeletons of one-celled organisms called "diatoms". These organisms lived in warm shallow seas and when they died, huge layers of them were left behind, over many centuries, when the seas dried up. They look like little sieves, and the water flows right through the skeleton. The holes in the skeleton are small enough the most dirt and bacteria will not flow through them and are trapped.

Hayward Pressure DE Filter Grid Complete Assembly

DE filters are used to filter fruit juices and beer products. DE is also an EPA registered insecticide, a frequent ingredient in toothpaste and scouring powder and has many other uses.

DE is a fine, white, floury powder when dry. It can be a health hazard if the dust is inhaled. It should not be handled dry.

DE provides the best filtration of the three types of filters addressed in this guide. A well operated filter run will filter out particles as small as 2 microns. This makes the DE filter effective at removing cryptosporidium oocysts, one of the pool operator's more difficult to handle disease-causing organisms.

DE filters have what are called "septa" (the plural of septum) These are support structures that come in a variety of shapes and sizes which are covered with a "sock" or fabric which traps and holds the DE during the filtration run. The DE coats the outside of the septa and the water passes through it into the inside of each septum and then into the piping to go back to the pool. This filter type can be either pressure or vacuum.

The flow rate for the DE filter is 2 GPM / sq. ft. While this is much slower than high rate sand, because of the septum design and spacing, filters of equivalent capacity take up fairly similar amounts of space.

To clean this filter, the water flow is reversed and the DE is released to go to a collection tank. The filter tank is drained and the septa are hosed off to remove the DE. The dirty DE is disposed of to solid waste disposal and new DE is used for the new filter cycle.

About every three months the septa are cleaned with a good degreasing solution to remove any oil buildup and sometimes then acid washed to remove any mineral buildup. They are checked to make sure there are no broken septum supports or holes in the "socks".

CARTRIDGE FILTERS

Cartridge Filters are pressure type filters (there are a very few vacuum types) that have a filter cartridge that fits inside the filter housing. This filter is removable for cleaning and is not cleaned in place, except that some very large cartridges may need to be hosed down in place to remove a portion of the dirt to allow them to be lifted out of the filter.

One of the main advantages of a cartridge filter is that the cleaning of the filter takes less water than what is normally used for sand or DE filter cleaning or backwashing. One disadvantage of the cartridges is that they are quite expensive and have to be replaced about every 1 – 5 years depending on the pool conditions.

The cartridges are usually a spun polyester fiber. The cartridges are constructed with an accordion pleat and look much like the air cleaner in your car. Because of the folding, a great deal of surface area can be packed into a fairly small amount of space.

The flow capacity of the cartridge filter for a cartridge filter with a capacity approximately that of sand fits inside the same approximate size filter vessel. By slowing down the flow even further, the cartridge filter can reach an effectiveness approaching that of the DE filter for particle removal, and very long filter runs have been achieved between cleanings.

To clean a cartridge filter, the filter tank is disassembled and the cartridge removed. Typically a clean cartridge is kept to immediately replace the dirty cartridge and the filter is quickly back in operation.

The removed filter element is hosed off to remove the dirt buildup. Sometimes a soft brush is used to help loosen the dirt. After the dirt is removed the cartridge should be soaked in a degreasing solution for several hours to overnight and then thoroughly rinsed. Occasionally this is followed by an acid wash in an acid solution. The filter is then thoroughly rinsed. Soaking in a disinfectant solution can remove the last dirt and grease and help disinfect the filter. Every filter should be allowed to air dry until completely dry to make sure the filter is completely disinfected and ready to return to filtration duty.

ORP – The Measurement of Oxidation Reduction Potential

ORP stands for “Oxidation-Reduction Potential.” In some parts of the world, it is also known as “Redox Potential.” ORP measures the relative tendency of different substances to lose or gain electrons. In pools, it is a measurement showing a disinfectant’s potential to oxidize contaminants.

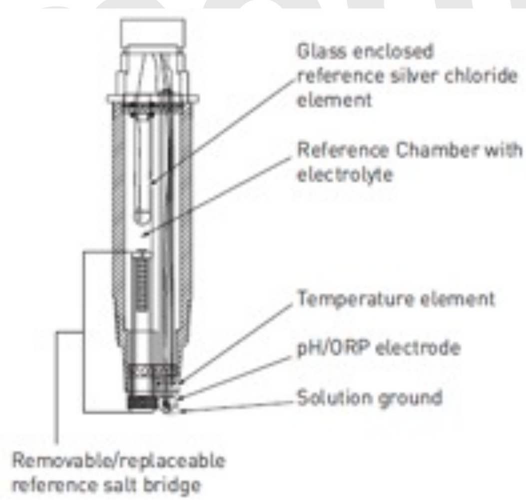
When chemists first used the term, the word "oxidation" meant "to combine with oxygen." We can see examples of oxidation all the time in our daily lives Oxidation can occur at different speeds. When we see a piece of iron rusting, or a slice of apple turning brown, we are looking at examples of relatively slow oxidation. When we look at a fire, we are witnessing an example of rapid oxidation. We now know that oxidation involves an exchange of electrons between two atoms. The atom that loses an electron in the process is said to be "oxidized." The one that gains an electron is said to be "reduced." The “reduced” atom no longer has an electrochemical potential, and the “oxidized” atom loses its attraction to the rest of its parent molecule. Chemicals like chlorine, bromine, and ozone are all oxidizers. It is their ability to oxidize - to "steal" electrons from other substances - that makes them good disinfectants, because in altering the chemical makeup of unwanted plants and animals, they kill them. Then they "burn up" the remains, leaving a few harmless chemicals as the by-product.

ORP is the only practical method we have to electronically monitor sanitizer effectiveness. The World Health Organization (WHO) has determined that an electrochemical potential (ORP) of 650 mV will disinfect drinking water. Because much of the “work” of the disinfectant is to oxidize materials as well, a minimum standard of 750 mV is used. This does not correlate to any particular part per million (ppm) measure, as there are many factors which effect the ORP reading.

ORP MEASUREMENT

Of all the factors involved in chemical maintenance; two, disinfectant residual and pH, are measured and adjusted most often. These are measured by a pool controller using the measurements from two different electrode probes inserted into the water stream.

When measuring ORP, an inert metal electrode is used to acquire the electrochemical potential of



electrons. Platinum and gold are the most common ORP electrode materials. The actual potential is measured between the metal electrode and a reference electrode. This measurement is the actual ability of the water and its components to oxidize; like a battery charged with stored disinfection and oxidation energy. Newer probes, with more highly refined electrodes, have a better ability to measure small changes in the ORP. These newer electrodes are used for High Resolution Redox (HRR) controllers. ORP and HRR essentially measure the same thing. The oxidation potential for a pool should be maintained at 750 mV or higher. Florida code specifies 700 to 850 mV.

pH DEPENDENCE

Chlorine ORP measurement is very pH dependent. As the pH of the solution rises, the ORP potential will decline. As we know, chlorine forms variable amounts of Hypochlorous Acid (HOCl is the active disinfectant) and Hypochlorite ions (OCl^- is inactive chlorine) depending on the pH. ORP is measures only the active chlorine (HOCl), other oxidizing disinfectants are measured similarly.

ORP ELECTRODE CONTAMINATION AND CLEANING

Generally, an ORP electrode will rapidly measure the ORP of the water. The speed and accuracy is dependent on the condition of the electrode. The electrode will collect grease that can be cleaned off with a common mild household degreaser. Spray it on, wait and rinse. Occasionally the electrode can collect some calcium deposits which can be removed from a platinum electrode with a mild solution of hydrochloric (muriatic) acid. Always degrease before acid cleaning. Cleaning the metal electrode with an abrasive material is not recommended. After chemical cleaning, the ORP electrode may exhibit unstable readings until it has stabilized. This stabilization may take overnight.

ORP ELECTRODE CALIBRATION

Since ORP is a characteristic measure of redox equilibrium, the ORP electrode should not require standardization or calibration. The measured potential is absolute. However, it is desirable to check instruments for proper operations and contamination.

Unfortunately, at this time, many state pool rules do not recognize ORP or HRR. Because of this, you will have to monitor both the ORP values, and the disinfectant ppm residuals required in the Florida code. It is fairly easy to use both by adjusting the pH up or down slightly until the ppm reading falls within the code requirements.

SAMPLE HOMEWORK PROBLEMS

Correct Answers Are Indicated by a Dark Numeral Such as ❶, ❷, ❸, or ❹

1. What is the surface area of a rectangular pool with a length of 10 meters and a width of 25 feet?

① 250 square feet ❷ 820 square feet ③ 750 square feet ④ 1000 square feet

Area for a rectangular pool (page 27 in textbook) is: Area = Length times Width

Remember meters times 3.28 = feet

	Length		Width		
Area =	☐	times	☐	=	☐
	in feet		in feet		

2. What is the volume of a rectangular pool with a length of 60 feet, a width of 30 feet, and a depth ranging from 3 feet in the shallow end to 7 feet in the deep end?

❶ 67,500 gallons ② 76,500 gallons ③ 62,800 gallons ④ 65,500 gallons

Volume (in gallons) for a rectangular pool (page 27 in textbook) is:

Gallons = Area times Average Depth times 7.5

	Shallow Depth		Deep Depth	
Average Depth =	☐	plus	☐	then divided by 2
	in feet		in feet	

	Length		Width		Avg. Depth	
Gallons =	☐	times	☐	times	☐	times 7.5
	in feet		in feet		in feet	

Gallons = ☐

3. What is the flow rate of a 50,000 gallon pool based on an 5.2 hour turnover rate?

① 208 GPM ❷ 160 GPM ③ 120 GPM ④ 114 GPM

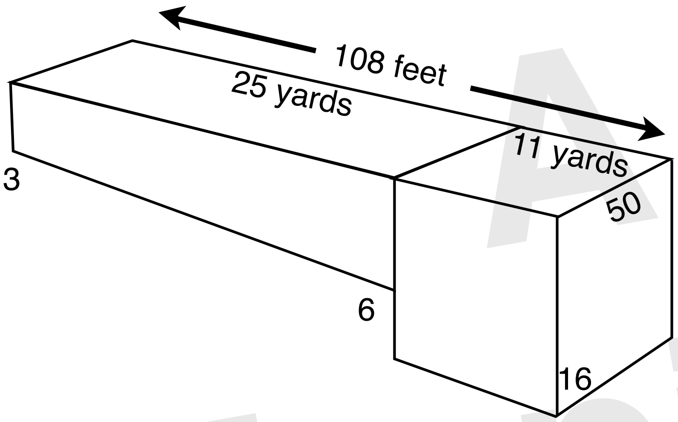
Flow Rate is:

Flow Rate = Pool Volume divided by Turnover Rate divided by 60 minutes per hour

	Volume		Turnover Rate		
Flow Rate =	☐	divided by	☐	divided by 60 =	☐
	in gallons		in hours		

4. Your pool is 108 feet long and 50 feet wide. The pool is divided into two areas: a swimming area and a dive well. The swimming area is 25 yards long with a depth from 3 feet to 6 feet. The diving well is 11 yards long and has a constant depth of 16 feet. What is the pool volume in gallons?

❶ 324,563 gallons ② 275,875 gallons ③ 175,560 gallons ④ 159,175 gallons



From page 27 & 28 of the textbook: Separate complex pools into their simple shapes, calculate each one separately, and add them back together.

Average Depth$_1$ = [Shallow Depth, in feet] plus [Deep Depth, in feet] then divided by 2

Gallons$_1$ = [Length, in feet] times [Width, in feet] times [Avg. Depth, in feet] times 7.5

Gallons$_1$ = [ ]

Gallons$_2$ = [Length, in feet] times [Width, in feet] times [Avg. Depth, in feet] times 7.5

Gallons$_2$ = [ ]

Total Gallons = [Pool 1] plus [Pool 2] = [Total]

5. Calculate the Saturation index for water that has a total alkalinity of 50 ppm, a pH of 7.0, a calcium hardness of 120 ppm, a temperature of 82°F, and a total dissolved solids of 400 ppm. Is it balanced, corrosive or scaling?

① + 1.0 ② − 0.6 ❸ − 1.0 ④ + 0.6

$$SI = pH + Tf + Cf + Af - TDSf$$

SI = Saturation Index; pH = pH as tested; Tf = Temperature factor; Cf = Calcium factor; Af = Alkalinity factor; TDSf = TDS factor

Use Illustration on page 14

	Test Kit Value	Index Factor
pH		
Temperature		
Calcium Hardness		
Total Alkalinity		
Sub-Total		
Total Dissolved Solids		—
Saturation Index		

6. What is the maximum flow rate of a pool with a cartridge filter of 851 square feet?

① 422 GPM ② 357 GPM ❸ 319 GPM ④ 297 GPM

Flow Rate is:

Flow Rate = Filter Area times Filter Media Rate (defined by Florida Code)

Flow Rate = Filter Area [ ] in Sq.Ft. times Filter Media Rate [ ] 0.375 in code = [ ]

7. How many BTU's does it take to raise the temperature of a 1000 gallon spa from 94° F to 102° F?

① 13,280 ② 6,640 ❸ 66,640 ④ 7,921

BTU's (by definition) = Gallons times **8.33** times °F temperature rise

	Volume				Number °F		
BTU's =	$\boxed{}$	times	**8.33**	times	$\boxed{}$	=	$\boxed{}$
	in gallons				Temp. Rise		

8. Adjust the CALCIUM HARDNESS from 120 ppm to 200 ppm in a 60,000 gallon pool. Use Calcium Chloride 77%.

① 43.2 ounces ② 43.2 pounds ③ 36.2 pounds ❹ 57.6 pounds

Use Illustration on page 15

CHEMICAL DOSAGE FOR YOUR POOL = SIZE FACTOR x CHANGE FACTOR x AMOUNT OF CHEMICAL

A is the ***Amount*** of Chemical on the ***Label***

B_1 is ***your*** Pool Gallons

B_2 is the Gallons on the ***Label*** (page 15)

C_1 is the ppm ***Change*** You Make

C_2 is the ppm Change on the ***Label*** (page 15)

B_1 = 60,000 Gallons: C_1 = 200 ppm minus 120 ppm = 80 ppm

Remember:

Ounces divided by 16 = pounds and **Fluid Ounces divided by 128** = gallons

A – Amount of Chemical using page 15	**B – Pool Volume** using gallons on label	**C – Change** using ppm on label
	B is B_1 divided by B_2 B_1 = ____________Gallons B_2 = ____________Gallons B = ____________	C is C_1 divided by C_2 C_1 = ____________ppm C_2 = ____________ppm C = ____________

	Amount		Size Factor		Change Factor
HMC =	$\boxed{}$	**times**	$\boxed{}$	**times**	$\boxed{}$

HMC = $\boxed{}$

9. What is the filter surface area needed for a D.E. filter if the flow rate is 650 GPM?

① 626 square feet ❷ 325 square feet ③ 525 square feet ④ 740 square feet

Filter Area is: Filter Area = Flow Rate divided by Filter Media Rate (given by Florida code for DE filters). It is 2 GPM/sq.ft.

		Flow Rate		Filter Media Rate		
Filter Area	=	[ ]	divided by	[ ]	=	[ ]
		in GPM		FL Code		

10. What is the flow rate of a 115,000 gallon pool based on a 6 hour turnover rate?

① 422 GPM ② 357 GPM ❸ 319 GPM ④ 297 GPM

Flow Rate is:

Flow Rate = Pool Volume divided by Turnover Rate divided by 60 minutes per hour

		Volume		Turnover Rate		
Flow Rate	=	[ ]	divided by	[ ]	divided by 60 =	[ ]
		in gallons		in hours		

11. What is the total filter area of a diatomaceous earth (DE) filter with 20 grids measuring 2 feet by 2.5 feet and filtering from both sides?

① 100 square feet ❷ 200 square feet ③ 400 square feet ④ 180 square feet

		Length		Width		Number
Filter Area	=	[ ]	times	[ ]	times **2** sides times	[ ]
		in feet		in feet		of grids

13. A spa contains 1,100 gallons of water and averages 15 people per day. How many days between replacing the water?

❶ 24 days ② 72 days ③ 7 days ④ Once per month

Replacement Interval (in days) (in some state codes is) is:

		Gallons		Users per day		Days
Days	=	[ ]	divided by **3** then divided by	[ ]	=	[ ]

Healthy Swimming

Fecal Accident Response Recommendations for Pool Staff*

What do you do when you find poop in the pool?

*Check for existing guidelines from your local or state regulatory agency before use. CDC recommendations do not replace existing state or local regulations or guidelines.

- These recommendations are for responding to fecal accidents in chlorinated recreational water venues.
- Improper handling of chlorine-based disinfectants can cause injury. Follow proper occupational safety and health requirements when following these recommendations.
- **Pool Closures:** Fecal accidents are a concern and an inconvenience to both pool operators and patrons. Pool operators should carefully explain to patrons why the pool needs to be closed in response to a fecal accident. Understanding that pool closure is necessary for proper disinfection and protection of the health and safety of swimmers is likely to promote support rather than frustration. Pool closures allow chlorine to do its job—to kill germs and help prevent Recreational Water Illnesses (RWIs).

www.cdc.gov/healthyswimming

SAFER • HEALTHIER • PEOPLE™

Important background info...

WHAT ARE RECREATIONAL WATER ILLNESSES (RWIs)?

What is the first thing that pops into your head when you think about water safety? Drowning? Slipping? Lightning? All good answers, and all are very important. But, did you know that germs can contaminate swimming water? These germs cause RWIs that have made many people sick.

RWIs are caused by germs such as "Crypto" (KRIP-toe), short for *Cryptosporidium*, *Giardia* (gee-ARE-dee-uh), *E. coli* 0157:H7, and *Shigella* (Shi-GEL-uh).

HOW ARE RWIs SPREAD?

RWIs are spread by swallowing pool water that has been contaminated with fecal matter. How? If someone has diarrhea, that person can easily contaminate the pool. Think about it. Pool water is shared by every swimmer. Really, it's communal bathing water. It's not sterile. It's not drinking water.

The good news is that germs causing RWIs are killed by chlorine. However, chlorine doesn't work right away. It takes time to kill germs and some germs like Crypto can live in pools for days. Even the best maintained pools can spread illness.

SHOULD ALL FECAL ACCIDENTS BE TREATED THE SAME?

No. A diarrheal fecal accident is a higher-risk event than a formed stool accident. With most diarrheal illnesses, the number of infectious germs found in each bowel movement decreases as the diarrhea stops and the person's bowel movements return to normal. Therefore, a formed stool is probably less of a risk than a diarrheal accident that you may not see.

A formed stool may contain no germs, a few, or many that can cause illness. You won't know. The germs that may be present are less likely to be released into the pool because they are mostly contained within the stool. However, formed stool also protects germs inside from being exposed to the chlorine in the pool, so prompt removal is necessary.

Germ Inactivation Time for Chlorinated Water*

Germ	Time
E. coli O157:H7 Bacterium	Less than 1 minute
Hepatitis A Virus	About 16 minutes
Giardia Parasite	About 45 minutes
Crypto Parasite	About 15,300 minutes or 10.6 days†

SHOULD YOU TREAT A FORMED FECAL ACCIDENT AS IF IT CONTAINS CRYPTO?

No. In 1999, pool staff volunteers from across the country collected almost 300 samples from fecal accidents that occurred at waterparks and pools.¶ CDC then tested these samples for Crypto and *Giardia*. None of the sampled fecal accidents tested positive for Crypto, but *Giardia* was found in 4.4% of the samples collected. These results suggest that formed fecal accidents pose only a very small Crypto threat but should be treated as a risk for spreading other germs (such as *Giardia*). Remember a diarrheal fecal accident is considered to be a higher-risk event than a formed-stool fecal accident.

* 1 ppm (1mg/L) chlorine at pH 7.5 and 77°F (25°C).

† Shields, JM; Arrowood, MJ; Hill, VR and Beach, MJ. (2007) Inactivation of *Cryptosporidium parvum* under chlorinated recreational water conditions. Journal of Water and Health. In Press.

¶ Prevalence of Parasites in Fecal Material from Chlorinated Swimming Pools — United States, 1999 (2001) MMWR Morb Mortal Wkly Rep (20):410–2.

What do I do about...

formed stool in the pool?

Formed stools can act as a container for germs. If the fecal matter is solid, removing the feces from the pool without breaking it apart will limit the degree of pool contamination. In addition, RWIs are more likely to be spread when someone who is ill with diarrhea has a fecal accident in the pool.

diarrhea in the pool?

Those who swim when ill with diarrhea place other swimmers at significant risk for getting sick. Diarrheal accidents are much more likely than formed stool to contain germs. Therefore, it is important that all pool managers stress to patrons that swimming when ill with diarrhea is an unhealthy pool behavior.

1. **For both formed-stool and diarrheal fecal accidents**, direct everyone to leave the pool. If you have multiple pools that use the same filter—all pools will have to be shut down. Do not allow anyone to enter the contaminated pool(s) until all decontamination procedures are completed.

2. **For both formed-stool and diarrheal fecal accidents**, remove as much of the fecal material as possible using a net or scoop and dispose of it in a sanitary manner. Clean and disinfect the net or scoop (e.g., after cleaning, leave the net or scoop immersed in the pool during disinfection).

VACUUMING STOOL FROM THE POOL IS NOT RECOMMENDED.

Formed stool in the pool:

3. Raise the chlorine to 2 ppm (if less than 2 ppm), and ensure the water's pH is between 7.2–7.5 and temperature is about 77°F (25°C). This chlorine concentration was selected to keep the pool closure time to approximately 30 minutes. Other concentrations or closure times can be used as long as the CT inactivation value* is kept constant (see next page).

4. Maintain the chlorine concentration at 2 ppm, pH 7.2–7.5, for at least 25 minutes before reopening the pool. State or local regulators may require higher chlorine levels in the presence of chlorine stabilizers,[†] which are known to slow disinfection. Ensure that the filtration system is operating while the pool reaches and maintains the proper free chlorine concentration during the disinfection process.

Diarrhea in the pool:

3. Raise the free chlorine concentration to 20 ppm (mg/L)[¶,§] and maintain the water's pH between 7.2–7.5 and temperature at about 77°F (25°C). The chlorine and pH should remain at these levels for at least 12.75 hours to achieve the CT inactivation value* of 15,300. **Crypto CT values are based on the inactivation of 99.9% of oocysts. Laboratory studies indicate that this level of Crypto inactivation cannot be reached in the presence of 50 ppm chlorine stabilizer,[†,**] even after 24 hours at 40 ppm free chlorine, pH 6.5 at a temperature of about 77°F (25°C).**

4. Ensure that the filtration system is operating while the pool reaches and maintains the proper chlorine level during disinfection. If necessary, before attempting the hyperchlorination of any pool, consult an aquatics professional to determine the feasibility, the most optimal and practical methods, and needed safety considerations.

5. Backwash the filter thoroughly after reaching the CT value. Be sure the effluent is discharged directly to waste and in accordance with state or local regulations. Do not return the backwash through the filter. Where appropriate, replace the filter media.

6. Allow swimmers back into the pool after the required CT value has been achieved and the chlorine level has been returned to the normal operating range allowed by the state or local regulatory authority.

Establish a fecal accident log. Document each fecal accident by recording date and time of the event, whether it involved formed stool or diarrhea, and the free chlorine and pH levels at the time or observation of the event. Before reopening the pool, record the free chlorine and pH levels, the procedures followed in response to the fecal accident (including the process used to increase chlorine levels if necessary), and the contact time.

* CT inactivation value (or contact time) refers to concentration (C) of free chlorine in ppm multiplied by time (T) in minutes at a specific pH and temperature.

† Chlorine stabilizers include compounds such as cyanuric acid, dichlor, and trichlor.

¶ Many conventional test kits cannot measure free chlorine levels this high. Use chlorine test strips that can measure free chlorine in a range that includes 20 ppm (such as those used in the food industry) or make dilutions with chlorine-free water when using a standard DPD test kit.

§ If pool operators want to use a different chlorine concentration or inactivation time, they need to ensure that CT values always remain the same (see next page for examples of how to accomplish this).

** CDC, unpublished data.

Pool disinfection time...

How long does it take to disinfect the pool after a fecal accident? This depends on what type of fecal accident has occurred and at which chlorine levels you choose to disinfect the pool. If the fecal accident is formed stool, follow Figure 1, which displays the specific time and chlorine levels needed to inactivate *Giardia*. If the fecal accident is diarrhea, follow Figure 2, which displays the specific time and chlorine levels needed to inactivate Crypto.

Figure 1-*Giardia* Inactivation for a Formed-Stool Fecal Accident

Chlorine Level (ppm)	Disinfection Time*
1.0	45 minutes
2.0	25 minutes
3.0	19 minutes

* These closure times are based on 99.9% inactivation of *Giardia* cysts by chlorine at pH 7.5, 77°F (25°C). The closure times were derived from the U.S. Environmental Protection Agency (EPA) Disinfection Profiling and Benchmarking Guidance Manual. These closure times do not take into account "dead spots" and other areas of poor pool water mixing.

Figure 2-Crypto Inactivation Time for a Diarrheal Fecal Accident

Chlorine Level (ppm)	Disinfection Time*†
1.0	15,300 minutes (255 hours)
10	1,530 minutes (25.5 hours)
20	765 minutes (12.75 hours)

* Shields, JM; Arrowood, MJ; Hill, VR and Beach, MJ. (2007) Inactivation of *Cryptosporidium parvum* under chlorinated recreational water conditions. Journal of Water and Health. In Press.

† At pH 7.5, 77°F (25°C).

The **CT inactivation value** is the concentration (C) of free chlorine in ppm multiplied by time (T) in minutes (CT value = C x T). The CT value for *Giardia* is 45 and the CT value for Crypto is 15,300 (both at about pH 7.5, 77°F [25°C]). If you choose to use a different chlorine concentration or inactivation time, you must ensure that the CT values remain the same.

For example, to determine the length of time needed to disinfect a pool after a diarrheal accident at 15 ppm, use the following formula: C x T = 15,300.

Solve for time: T = 15,300 ÷ 15 ppm = 1020 minutes or 17 hours. It would take 17 hours to inactivate Crypto at 15 ppm. You can do the same for *Giardia* by using the CT inactivation value of 45.

Reducing Illnesses at Indoor Waterparks

Summary

Lifeguards and patrons in the rapidly growing indoor waterpark industry can be exposed to numerous disinfection byproducts (DBP) and microorganisms that can cause adverse health effects such as eye and respiratory irritation, skin rashes, and flu-like symptoms. NIOSH provided technical assistance to a county health department to investigate the cause of symptoms reported by employees of a large indoor waterpark. This document addresses issues that pool managers, designers, and public health officials should consider to reduce illness at indoor water parks.

Description of Exposure

The mixture of disinfectants, such as chlorine, and compounds found in pool water can produce many DBPs, which can dissipate into the air; microorganisms may also be present in water and can make people sick. Also, indoor waterparks have many splash and spray features that can aerosolize contaminants from the water into the air, where patrons and employees can inhale them (see Figures 1 and 2). These features can make managing this environment more difficult than in still-water pools.

Waterparks can have high numbers of patrons, including young children, spending long lengths of time in the waterpark area, which can be a major contributing factor to DBP production because they produce sweat and urine. The average amount of urine, which contains nitrogenous compounds, released into pool waters per bather is 25 to 30 milliliters [Gunkel and Jessen 1988], and each liter of sweat contains one gram of nitrogen [WHO 2006]. As more sweat and urine are released into the pool water, the nitrogen-containing compounds also increase which can chemically mix with disinfectants to create irritating DBPs in the air.

Lifeguards and employees working inside an enclosed waterpark for long durations may be at higher risk of having symptoms of exposure to DBPs because they work long hours with fewer breaks than those who work outside the enclosed area.

Chloramines and Endotoxins

Chloramines are DBPs that form when chlorine combines with nitrogen-containing compounds from sweat or urine. Chloramines, specifically trichloramine, are suspected as a primary cause of reported irritation symptoms based on exposure monitoring studies [Hery et al. 1995; Massin et al. 1998]. People exposed to trichloramine may experience respiratory symptoms such as cough, chest tightness, wheezing, and eye irritation. In addition to the number of people using the pool, other factors that affect the chloramine concentration in indoor waterparks include water chemistry parameters (e.g., chlorine concentration, pH, temperature), aerosolization of particles caused by splashing and spraying, and air recirculation from the ventilation system [Hery et al. 1995; Massin et al. 1998].

Endotoxin, which is found in the cell wall of certain bacteria, is released when the bacterial cell breaks down or multiplies. It has been found in various industrial and nonindustrial settings associated with bacterial contamination, humidifiers, air conditioners, and other water-associated processes. It can cause airway and alveolar inflammation as well as chest tightness, fever, and malaise and acute reduction in lung function.

Case Study

NIOSH assisted a local heath department to investigate eye and respiratory

Visit the CDC/NOSH website for full article
http://www.cdc.gov/niosh/

Hot Tub User Information: Protect Yourself from Recreational Water Illnesses and Stay **HOT**!

Heed...hot tub rules for safe and healthy use.

- Refrain from entering a hot tub when you have diarrhea.
- Avoid swallowing hot tub water or even getting it into your mouth.
- Shower or bathe with soap before entering the hot tub.
- Observe limits, if posted, on the maximum allowable number of bathers.
- Exclude children less than 5 years of age from using hot tubs.
- If pregnant, consult a physician before hot tub use, particularly in the first trimester.

Observe...and listen to the hot tub and its surroundings. What should you notice?

- No odor; a well-chlorinated hot tub has little odor. A strong chemical smell indicates a maintenance problem.
- Smooth hot tub sides; tiles should not be sticky or slippery.
- Hot tub equipment is working; pumps and filtration systems make noise and you should hear them running.
- Hot tub temperature; the water temperature should not exceed 104˚F (40˚C)
- Check the hot tub water; test for adequate disinfectant (4–6 parts per million) and pH (7.2–7.8) levels. Pool and hot tub disinfectant test strips are available at local home improvement stores, discount retailers and pool supply stores. If you want to practice using them at home, visit: http://www.cdc.gov/healthywater/swimming/pools/pool-spa-test-strip-instructions.html.

Talk...to hot tub owners/staff and other hot tub users.

- What was the health inspector's grade for the hot tub after its last inspection?
- Are chlorine and pH levels checked at least twice per day?
- Are these levels checked during times when the hot tub is most heavily used?
- Are trained operation staff available during the weekends when the hot tub is most heavily used?
- What specialized training did the staff take to prepare for working at or operating a hot tub?
- Learn about RWIs and educate other users and your hot tub operator.
- Urge your hot tub management to spread the word about RWIs to hot tub staff and pool users.

Healthy Swimming

OTHER FLORIDA AND FEDERAL RESOURCES

DOH Public Swimming Pools and Bathing Places Code (current)

http://www.doh.state.fl.us/environment/water/swim/pdfs/64E-9_FAC_Draft_Rev7_no_strike.pdf

State of Florida Contractor's Licensing Title XXXII Chapter 489

http://www.leg.state.fl.us/Statutes/

Consumer Product Safety Commission Fence Barrier Guidelines

http://www.doh.state.fl.us/environment/water/swim/pdfs/CPSC_Safety_Barriers_Pool.pdf

Centers for Disease Controls and Prevention – Healthy Swimming

http://www.cdc.gov/healthywater/swimming/

Department of Justice ADA Standards Swimming Pools

http://www.justice.gov/opa/pr/2012/May/12-crt-649.html

OSHA Hazard Communication

http://www.osha.gov/dsg/hazcom/msdsformat.html

PERIODICALS AND INFORMATIONAL RESOURCES

Aqua Magazine

http://aquamagazine.com/content/

Aquatics International

http://www.aquaticsintl.com

Pool and Spa News

http://www.poolspanews.com

Service Industry News

http://www.poolspa.com/publications/sin/

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