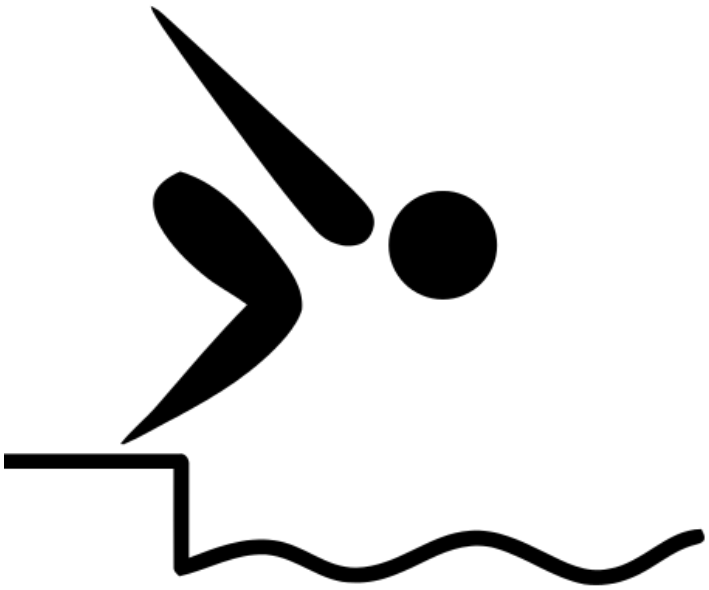
JOHNSON COUNTY
KANSAS
Health & Environment

Swimming Pool Program Reference Material December, 2017

Johnson County Department of Health and Environment
Environmental Division
Guide to Swimming Pool Operation

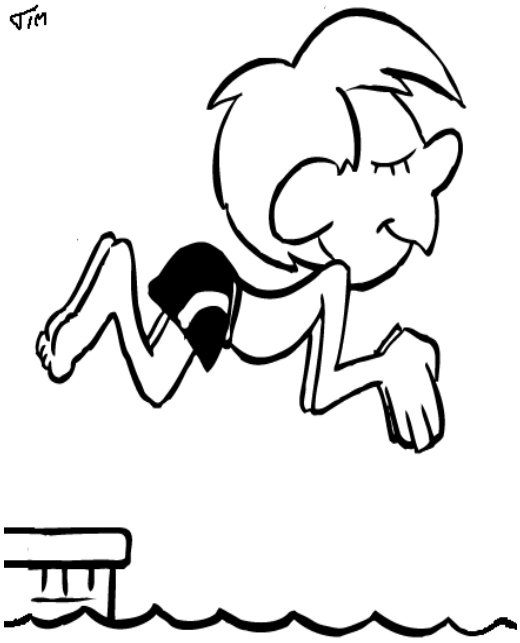
Table of Contents



Swimming Pools and Health

Pools that are not well-constructed, operated, and maintained may become a public health problem.

Diseases of Concern:



1. Intestinal Diseases - Typhoid fever, parasitic infection, paratyphoid fever, amoebic dysentery, leptospirosis, and bacillary dysentery are just a few of the diseases which can be a problem when swimming pool water is polluted by domestic wastes.

2. Respiratory Diseases - Colds, sinusitis, and septic sore throat can be spread more rapidly in swimming pools due to the close contact, coupled with lowered resistance of the swimmers due to exertion.

3. Eye, Ear, Nose, Throat, and Skin Infections - The exposure of delicate mucous membranes, the movement of harmful organisms into ear and nasal passages, the excessive use of water treatment chemicals, and the presence of harmful agents in the pool water can contribute to eye, ear, nose, throat, and skin infections.

Injuries:

Drowning deaths are by far the greatest potential problem at swimming pools. Lack of supervision is a prime reason for drownings. Improper construction, use, and maintenance of swimming pools can also cause drownings to occur.

Other problem areas contributing to injuries include loose diving boards, poorly located slides, projecting or exposed pipes, improperly installed or maintained electrical equipment, improperly ventilated chlorinators, and hazardous objects, such as glass within the pool area.

Basic Principles for Safe Healthful Swimming:

1. Reduce the introduction of infectious material into the pool by mandating personal cleanliness of swimmers and using proper design features to preclude introduction of surface drainage and windblown debris from surrounding areas.

2. Remove or destroy as rapidly as possible any dirt and infectious material introduced into the swimming pool by continuously disinfecting the pool water and recirculating the water through a properly designed filtration system which meets minimum turnover rates.

3. Construct and operate the pools in a satisfactory manner by installing equipment and its appurtenances in accordance with manufacturer’s instructions. Closely supervise the pool while open to prevent accidents.

Bathhouse Operation and Maintenance:

1. Lavatories, urinals, toilets, and showers must be cleaned and disinfected at least daily, or more frequently if needed. Soap, toilet tissue and disposable towels or hot air blower must be available at all times.

2. To clean and sanitize floors, add 1 cup liquid soap and 2 cups household bleach (5.25% chlorine by weight) to 3 gallons of water in mop bucket.

3. Avoid using wooden walkways and floor mats which are extremely difficult to disinfect and will harbor infectious bacteria and other organisms such as the fungus that causes athlete's foot.

Water Filtration

Pool water must travel through a filtration system consisting of sand, diatomaceous ea1th, or cartridge type media. The media suspends or traps large particles to physically clean the water. Over time, the media will need cleaning. Backwashing or pressure spraying the filter media will clean the media of entrapped particles.

Why the Need for Filtration?

1. Filth - Contaminants are constantly introduced into the water from patrons, leaves, grass, etc. Filters are used to remove suspended contaminants. Sand and dirt from sidewalks, lint, hair, make-up, face creams, soap, suntan lotion, and body waste must be removed in order to maintain a clear, sparkling water.

2. Clarity - An adequately sized filtration system is necessary to maintain clean, clear swimming pool water. Clarity of pool water must be such that the main drain grate is readily visible from the pool deck or a black disc six (6) inches in diameter placed at the deepest point is clearly visible from the deck of the pool. Good water clarity is essential to observe swimmers and spot drowning victims.

What Factors Affect Filtration Effectiveness?

1. Turnover Rate - To help achieve good clarity, the entire water volume in a swimming pool must travel through the filter at least once every eight hours. Since spas and wading pools are subject to heavier usage per volume of water, their turnover rates must be higher. Spas must produce one turnover every thirty minutes. Wading pools must accomplish one turnover every two hours.

Turnover rates are calculated by using the flowmeter on the filtration system. Flowmeters indicate the amount of water flowing through the recirculation system in gallons per minute (gpm). Turnover rates are expressed in hours. The following formula to calculate the turnover rate in hours:

TURNOVER RATE
Total water volume in gallons ÷ gpm from flowmeter ÷ 60 = Turnover rate in hours

2. Filtration Size - Sizing a filtration system is dependent upon the type of filtration system employed, desired turnover rate and gallons of water treated.

Disinfection of Swimming Pool Water

Filtration alone is not sufficient to ensure water safety. Bacteria must be chemically destroyed. Chlorine or bromine must be consistently maintained within a pool to destroy disease-causing bacteria.

Why Disinfect Swimming Pool Water?

1. Oxidize Wastes - Wastes are introduced into the swimming pool water through various sources. Examples include grass clippings, debris blowing into the pool water, patrons using the swimming pool facility, etc.

2. Disease - Bacteria from body wastes, perspiration, soaps, creams, suntan lotion, hair, sand and dirt can all contribute to the bacterial growth and possible spread of disease through pool water.

Combined Available Chlorine Residual (CAC) - The addition of ammonia and other nitrogen-containing organic compounds through contaminants such as perspiration, saliva and body oils to pool water can chemically combine with chlorine to produce unwanted disinfecting compounds known as CAC or chloramines. Although these compounds will destroy microorganisms, their kill rate is much slower than Free Available Chlorine (FAC). In addition, CAC will cause skin and eye irritation, as well as a foul chlorine odor. Therefore, all chlorine in the pool should exist as FAC. Periodic testing of the water is mandatory to ensure CAC is not present.

Types of Chemicals Used to Disinfect Swimming Pools:

1. Chlorine Gas - Chlorine gas cylinders are available in 150 pound cylinders or 1 ton steel tanks. Gas chlorine is very cost effective by providing 100% available chlorine. However, its use requires following very strict safety measures such as a gas mask, specific room ventilation, and complete separation of the chlorinator room from the rest of the facility.

2. Calcium Hypochlorite - This product is sold in powdered or tablet form, having concentrations from 70% available chlorine or lower. Proper storage and handling is essential to prevent combustion. If this product contacts organic substances such as suntan oil, carbonated drinks or perspiration, a fire could result.

3. Sodium Hypochlorite - Sodium hypochlorite is a liquid form of chlorine available commercially in varying strengths from 12% to 15%. The liquid has a short shelf life and must be used rapidly to avoid losing chlorine strength.

4. Lithium Hypochlorite - Lithium hypochlorite is available in powdered form and contains 35% available chlorine. The product dissolves well in water, but is usually cost-prohibitive.

5. Chlorinated Isocyanurates (Stabilized Chlorine) - Two forms of stabilized chlorine consist of either sodium dichloro-s-triazinetrione “dichlor” or trichloro-s-triazinetrione “trichlor.” Both forms contain the stabilizer, cyanuric acid. Dichlor is highly soluble in water and provides 56% to 62% available chlorine. Trichlor is more popular and provides 90% available chlorine. The biggest advantage of dichlor and trichlor is their resistance to decomposition in sunlight.

6. Bromine - Bromine, like chlorine, is a member of the halogen family and is available to the pool industry in tablet form. A minimum residual of 2.0 ppm must be maintained.

Control of pH

pH is a chemical term used to express the degree of acidity or alkalinity of a substance with values ranging from 0 to 14. A pH value of 7.0 is neutral, which means a substance is not acidic or alkaline. Dichlor is the only form of chlorine used by the pool industry with a near-neutral pH of 6.9. For any value below 7.0, the substance is acidic. The smaller the number, the more acidic the substance is. On the other hand, any value above 7.0 means the substance is alkaline (e.g., sodium hypochlorite has a pH of 13), and the larger the number, the more alkaline the substance is.

Why Is pH Important?

1. Disinfection - If pH is above 7.8, the effectiveness of chlorine disinfection is dramatically reduced and waterborne diseases are more likely to be transmitted.

2. Swimmer Comfort - A pH level below 7.0 or above 8.4 will result in skin and eye irritation.

3. Water pH lower than 7.0 is said to be acidic, and the smaller the number, the more acidic the water is. Corrosive damage to pipes, filters, and pumps may result if pH is allowed to remain at levels below the ideal 7.2 to 7.8 range.

4. Water pH above 7.0 is said to be basic (alkaline), and the higher the number, the more basic the water is. Scale forming deposits from minerals in the water may adhere to the swimming pool bottom and walls, causing them to become rough. Piping, pumps and filters may become clogged with these deposits if pH is allowed to remain at levels above the ideal 7.2 to 7.8 range.

Factors That Affect pH Levels:

1. Disinfectants can raise or lower the pH. Gaseous chlorine, bromine tablets and trichlor tablets tend to lower pH while all hypochlorite compounds raise pH.

2. Coagulants, such as alum, will lower pH, but should NEVER be used for pH control.

3. Fresh Water - The make-up water added to the pool can cause a considerable change in pH if it is high in alkalinity or acidity.

Additives to Raise pH:

1. Soda Ash (Sodium Carbonate) - This compound is most commonly used to raise pH. Eight (8) ounces of soda ash will raise pH from 7.0 to 7.4 for each 10,000 gallons of water in the pool.

2. Caustic Soda (Sodium Hydroxide or Lye) - This compound is a stronger base than soda ash. Usage is usually limited to larger swimming pools with gas chlorinators.

3. Baking Soda (Sodium Bicarbonate) - This product is a weak base which can be used to raise pH of pool water, but is more commonly used for total alkalinity adjustments.

Additives to Lower pH:

1. Sodium Bisulfate (Sodium Acid Sulfate) - This compound is much safer to use than muriatic acid and has the additional benefit of removing lime deposits from chemical feed lines, sand filters, and piping. Consult product label for proper dosage instructions.

2. Muriatic Acid (Hydrochloric Acid) - This liquid is much more hazardous to handle than Sodium Bisulfate and should be used only if proper safety measures are in place. If handled improperly, muriatic acid can cause injury to the pool operator, the swimmer, and the equipment. For personal safety, always consult Material Safety Data Sheets (MSDS) prior to using or handling hazardous chemicals. MSDS are provided from the manufacturer of pool chemicals and must be kept on-site for reference.

Total Alkalinity

Total alkalinity is a measure of the extent to which water is buffered or made to respond to pH adjustment. Buffering capacity of the swimming pool water means that the pH of the water is resistant to change. Total alkalinity is measured in parts per million (ppm) of calcium carbonate (CaCO3). Water with a very low total alkalinity may radically respond to pH correction, while water with proper total alkalinity might respond very little or not at all when acid is added.

Why Control Total Alkalinity?

The pool operator will find that the pH will not rapidly fluctuate if the total alkalinity has been stabilized between 100 to 125 ppm for plaster pools, 80 to 150 ppm for spas and 125-150 ppm for painted and fiberglass pools.

Additives to Increase Total Alkalinity:

1. Sodium bicarbonate (baking soda) will increase total alkalinity by 30 ppm when 4.5 pounds per 10,000 gallons of pool water is added. Sodium bicarbonate will also raise the pH of the water.

Additives to Decrease Total Alkalinity:

1. Muriatic acid will decrease total alkalinity by 30 ppm when two (2) quarts per 10,000 gallons of pool water is added. Muriatic acid also dramatically lowers the pH of pool water.

2. Sodium bisulfate will also decrease total alkalinity by 30 ppm when 4.75 pounds per 10,000 gallons of pool water is added. Sodium bisulfate will also lower the pH of pool water.

Algae Control

Algae are plant forms brought in by the wind and fresh make-up water. They grow quickly in the presence of sunlight. Some types of algae are free floating and others are clinging. The clinging type will embed itself into the pores and crevices in the pool walls and floor and are much more difficult to remove and treat.

Why Control Algae?

1. Chlorine Demand - Since algae are organic in nature, they will create a high chlorine demand; and once they have begun to grow in the swimming pool, the maintenance of an adequate chlorine residual is very difficult.

2. Water Turbidity - The increased turbidity in the pool due to algae is not only aesthetically objectionable, it also creates a hazard to proper swimmer supervision.

3. Effect on Bacterial Growth - Algae actually protects bacteria from the effects of chlorine by creating a high chlorine demand themselves; thus algae may also foster the growth of bacteria.

4. Slipping - Algae growths on pool bottoms, ladders, walkways, and sides create slick surfaces which can contribute to accidents.

Detecting Algae Early:

Because algae require carbon dioxide to grow and deplete carbon dioxide from the swimming pool water, there will be a dramatic increase in the pH. For example, swimming pool water can jump from 7.5 to 8.0 in several hours.

This radical jump in pH can help the pool operator detect signs of early algae problems before noticeable growth appears in the pool water. Algae can turn an entire pool dark green in as little as a day or two.

Methods of Control:

1. Routine Chlorination - Maintaining an adequate FAC residual will prevent the start of algae problems.

2. Pool Shading - Since algae require sunlight to grow, the shading of the pool will slow the growth of algae but will not prevent it.

3. Temperature - Warm water temperature above 80 degrees Fahrenheit promote algae growth. Water temperatures maintained below 80 degrees Fahrenheit will be resistant to algae growth.

4. Copper Sulfate - Pools that continually experience algae growth problems control algae by maintenance dosing the pool with copper sulfate. Always consult container label for proper dosage amounts.

Two possible problems that can result with the usage of copper sulfate include discoloring of swimming suits and the bather’s hair. Copper sulfate may also have a drying effect on the mucous membranes.

5. Superchlorination (Shock Treatment) - Superchlorination is one of the most effective treatments to control algae. A FAC residual of 10 ppm in the pool during non-swimming hours must be rapidly attained. Calcium hypochlorite is most commonly used for shock treatments. In most cases, automatic chlorinators cannot raise the chlorine residuals fast enough. Super chlorination should be performed routinely (e.g., once per week) to prevent algae growths.

Following superchlorination, high chlorine residuals must be reduced to permit swimming. Sodium thiosulfate is an effective chlorine neutralizer. One (I) ounce of sodium thiosulfate will lower the FAC level one (1) ppm in 10,000 gallons of water. Fresh water can also be used to lower chlorine residuals. Always ensure proper chemical balance before reopening a pool.

6. Pool Scrubbing - As a last resort, the pool may be completely drained and the bottom and sides scrubbed with a 5% hypochlorite solution to remove embedded algae growths.

7. Pool Paints - Durable and smooth surfaces created by painting with a rubber-based waterproof enamel paint will help resist clinging algae.

Appendix A: Swimming Pool Calculation and Information

Since all pool chemicals are labeled for dosages per quantities of pool water, usually 10,000 or 5,000 gallons, you must be able to calculate the quantity of water in your pool. The first step includes calculating the amount of surface area. Surface area is a two dimensional figure that includes only the length and width of a pool. The following formulas are used to calculate surface area:

1. Surface Area of a Swimming Pool Expressed in Square Feet:

Rectangular Pool = length x width = square feet of surface area
Circular Pool = 3.14 x $(radius)^2$ = square feet of surface area
Radius = 0.5 x diameter, or drawing a line from the center of the pool to its outer edge

To calculate the square feet of surface area of the rectangular pool:
40 ft. x 20 ft. = 800 sq. ft.

To calculate the square feet of **surface area** of the circular pool with a 30 ft. diameter:
Radius = 0.5 x 30 ft. = 15 ft.
$Radius^2$ = 15 ft. x 15 ft. = 225 sq. ft.
Square feet of **surface area** = 3.14 x 225 sq. ft. = 706.5 sq. ft.

2. The next step to determine water volume uses the average water depth. To calculate the average water depth in the rectangular pool:

Average depth = (Deepest Water Depth + Shallowest Water Depth) ÷ 2
(6 ft. + 3 ft.) ÷ 2 = 4.5 ft.

3. The final step in water volume calculations involves using the preceding two calculations (surface area and average depth), then multiplying by 7.48 to express the answer in gallons. There are 7.48 gallons per cubic foot of water.

Water Volume of a Swimming Pool in Gallons

Surface area x average depth x 7.48 = gallons

Rectangular Pool Volume = 800 square feet x 4.5 feet x 7.48 = 26,928 gallons
Circular Pool Volume = 706.5 square feet x 5 feet x 7.48 = 26,423.1 gallons (rounds to 26,423 gallons)

Appendix B:

Dosages Required to Chemically Treat 10,000 Gallons of Water

Chemical	Desired Change		
Increase Chlorine	**1 ppm**	**5 ppm**	**10 ppm**
Calcium Hypochlorite (67%)*	2 oz.	10 oz.	1.3 lb.
Sodium Hypochlorite (12%)	10.7 fl. oz.	1.7 qt.	3.3 qt.
Lithium Hypochlorite	3.8 oz.	1.2 lb.	2.4 lb.
DiChlor (62%)	2.1 oz.	10.5 oz.	1.3 lb.
DiChlor (56%)	2.4 oz.	12 oz.	1.5 lb.
TriChlor	1.5 oz.	7.5 oz.	15 oz.
Decrease 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 lb.
Increase Total Alkalinity	**10 ppm**	**30 ppm**	**50 ppm**
Sodium Bicarbonate	1.4 lb.	4.2 lb.	7.0 lb.
Sodium Carbonate (soda ash)	14 oz.	2.6 lb.	4.4 lb.
Decrease Total Alkalinity	**10 ppm**	**30 ppm**	**50 ppm**
Muriatic Acid (31.4%)	26 fl. oz.	2.4 qt.	1 gal.
Sodium Bisulfate	2.1 lb.	6.4 lb.	10.5 lb.
Increase pH	**7.2 - 7.4**	**7.0 - 7.4**	**6.6 - 7.4**
Sodium Carbonate (soda ash)	6 oz.	8 oz.	12 oz.
Decrease pH	**7.8 - 7.6**	**8.0 - 7.6**	
Muriatic Acid (31.4%)	12 fl. oz.	16 fl. oz.	
Increase Calcium Hardness	**10 ppm**	**30 ppm**	**50 ppm**
Calcium Chloride (100%)	0.9 lb.	2.8 lb.	4.6 lb.
Calcium Chloride (77%)	1.2 lb.	3.6 lb.	6.0 lb.
Increase stabilizer	**5 ppm**	**10 ppm**	**30 ppm**
Cyanuric Acid (CYA)	6.5 oz.	13 oz.	2.5 lb.
A Cyanuric Acid concentration above 50 ppm is **not recommended**.			
Cyanuric Acid concentrations above 50 ppm requires **double the concentration** of chlorine for hyperchlorination to control cryptosporidium, **40 ppm vs 20 ppm**.			
Use of Cyanuric Acid and/or stabilized chlorine for indoor pools is **not recommended**.			

Appendix C:

Common Pool Problems

Condition	Causes	Remedies
1. Turbidity or milky water	-Improper filter operation -Possibly algae if water is green -pH too high -Total alkalinity too high	1. Review, inspect and backwash filter system 2. Superchlorinate 3. Adjust pH or total alkalinity down with acid 4. Replace filter element
2. Brown or red water	-High iron and manganese content, also silt	1. Superchlorinate 2. Flocculate with alum 3. Filter and vacuum
3. Eye irritation	-pH too low or too high	1. Add soda ash to raise pH to 7.2-7.8 2. Add acid to lower pH 3. Superchlorinate to destroy chloramines
4. Scale formation or white ring	-Water hardness - high in calcium and magnesium and pH too high	1. Maintain pH in the range of 7.2-7.8
5. Black algae spots	-Black algae clinging to sides and bottom	1. Use algicide formulated to control black algae 2. Superchlorinate 3. Scrub spots with a stiff brush
6. Bacteria	-Lack of adequate disinfection	1. Chlorinate to 1-3 ppm 2. Check accuracy of test kit
7. Green or brown algae water and slimy pool walls	-Algae build-up usually caused by inadequate chlorination	1. Superchlorinate 2. Use algicide 3. Filter and back wash till water clears
8. Metal corroding or hazy green water	-pH too low and pool water dissolves iron from the pool pipes and filters	1. Raise and maintain pH level with soda ash 7.2-7.8