The Professional Swimming Pool Operator's

Swimming Pool and Spa Operator's Handbook

AQUATIC TRAINING & CONSULTING SERVICES

Creating Pool Professionals Worldwide

www.aquatictrainingservice.com

AQUATIC TRAINING &
CONSULTING SERVICES

Aquatic Training & Consulting Service
448 W South Street
Frederick MD 21701
301-760-7114
rob@aquatictrainingservice.com

Welcome to your swimming pool operator course!

Swimming attracts more than 125 million participants annually. This figure represents nearly half of the United States population. Swimming continues to be one of the most popular recreational activities in the United States. There are an estimated 10 million pools in this country that support fitness, relaxation, instruction, competition, and therapy for their patrons. Because of this amount of activity, aquatic facilities need appropriately trained operators to oversee their operations.

This manual helps provide a basis for pool operator instruction. It heavily relies on the information provided by the Maryland State Health Department's Code of Maryland Annotated Regulations, the Model Aquatic Health Code, and the executive regulations of local and state health departments in the Washington DC Metropolitan Area. The material in this manual compiles various texts, experiences of ATCS staff, other pool operator course materials, and the input of other aquatic professionals. We intend that this information will begin your education in swimming pool operation, certainly not complete it. We view this manual as a "work in progress" and will change information as new and updated information becomes available to our staff. It is up to you as a new pool operator to keep yourselves up to date on the ever-changing rules and regulations of running aquatic facilities.

With the information provided in this manual, we hope you can offer a safe and enjoyable experience for your patrons. We also invite your input about the information provided in this course. If any areas need to be covered in greater detail or require correction, please let us know at rob@aquatictrainingservice.com. If you have questions regarding the proper operations of your swimming pool, please contact ATCS, other pool professionals for assistance, or your local Health Department.

Happy operating,

Rob Fox

ATCS President

CHAPTER ONE

My New Job: Professional Swimming Pool Operator (PSPO)

Chapter Objectives

1. Identify the basic do's and don'ts of swimming pool operation
2. List the essential job responsibilities of a Pool Operator.
3. List the primary job responsibilities of a Pool Manager.
4. Identify your role in hiring, training, and supervising lifeguards at your facility.
5. Understand the need to have and implement a site-specific emergency action plan.
6. List the criteria necessary to develop a site-specific accident report.
7. Understand the dangers that present themselves at a swimming pool

12 Reasons Why The Health Department Will Close Your Pool:

1. No certified operator on duty.
2. Lifeguard with current certifications not present.
3. Chemicals are out of balance. (especially Chlorine and pH)
4. Chemical feeders are not operating for more than 24 hours.
5. The filtration system is not working for more than 1 hour.
6. Water is below the skimmers.
7. The main drain is not easily visible.
8. Bathrooms and deck drains are not operational.
9. The facility presents a danger to patrons.
10. Flowrate is insufficient for adequate turnover.
11. The phone is not operational.
12. The Health Inspector is denied access to the facility.

Basic Pool Operation Information: Things the PSPO Can't Forget

1. A registered Pool Operator must be present for the pool to be open.
2. Lifeguard to swimmer ratio cannot exceed a ratio of 50:1 (ATCS recommends 25:1)
3. Some of the factors that affect the number of guards required to monitor a facility safely are the following: the number of guards on duty, number of swimmers in the water, the skill level of swimmers, the shape of facility, temperature, and activity.
4. Pool readings in a main pool must be taken every 2 hours for Chlorine and pH. In a main pool, Total Alkalinity, Calcium Hardness, and Cyanuric Acid must be taken once per week. (Spas and Wading Pools have different requirements.)
5. Each pool must have a working phone for emergency calls, or the pool should not be opened. Cell phones are not acceptable.
6. The lifeguard must be located on the pool deck and watching the pool.
7. Pool certifications (PSPO, Lifeguard, & CPR certifications) must be posted in the guard room. The health department is not obligated and often will not accept copies of certifications.

Montgomery County, MD Regulations

IF YOU ARE TAKING THE MONTGOMERY COUNTY MD POOL OPERATOR TEST THESE ARE THE 11 REASONS THAT YOU MUST KNOW SWIMMING POOL SUMMARY ENFORCEMENT (11 REASONS FOR CLOSURE). When any of the following conditions exist at any public pool, the pool permit is suspended, and the pool is closed until the situation is corrected. The pool will not reopen until it has been inspected by the director, and the director has approved it to open.

1. A lifeguard is not on the pool deck of a general use pool, or a spa guard is not on the premises of a spa.
2. The main drain is not clearly visible from the nearest lifeguard chair or the furthest edge of the pool if the pool has no lifeguard chair.
3. The free chlorine, total bromine, pH, or cyanuric acid readings of the pool water are other than specified under Section II, B.1.
4. The recirculating equipment is not working correctly for more than one hour.
5. The water level is below the skimmers in pools using this method of circulation.
6. The chemical disinfectant feeder has not been functional for a period of 24 hours; provided that pH, free chlorine, total bromine, or other approved disinfectant residuals are maintained in accordance with Section II, Water Quality.
7. The bathhouse drainage system is blocked sufficiently to render the bathhouse unusable; water is not available at sufficient pressure to operate the bathhouse, waste disposal systems are inoperable, unsanitary conditions exist, or the bathhouse is unusable for other health or safety reasons.
8. The director has been wrongfully denied permission to inspect the pool pursuant to Chapter 51 and these regulations.
9. A licensed Montgomery County pool operator is not in immediate control of the pool.
10. The director determines that an immediate hazard exists to the health or safety of the users of any pool.
11. At least one lifeguard currently certified in infant/child/adult CPR is not within the pool enclosure.

Professional Swimming Pool Operator (PSPO) Job Description

People like a swimming pool or spa that looks great! If it looks blue and clear, it is much more inviting to the patrons using the facility. Pools and spas require daily maintenance. Most jurisdictions require that a registered pool/spa operator is in immediate control at each facility. These individuals are not only tasked with the look of the facility but the safety of the water and its surrounding environment to its patrons. A Professional Swimming Pool Operator is someone with swimming pool/spa operations knowledge, including but not limited to water disinfection, water balance, pool circulation, filtration, and other topics related to disease prevention and pool maintenance. To become a pool operator, many jurisdictions have a minimum age requirement and require the successful completion of an approved course and /or passing an exam. Each jurisdiction may have different guiding regulations.

Most local Health Departments' Regulations for a Swimming Pool Operator are:

- Must be 16 years old,
- complete an approved course, and
- receive a 75% or better on the exam

The following is a general list of responsibilities found in the Maryland State Health Code. *Reprinted from an exert of COMAR 10.17.01*

1. To conduct an inspection of the pool or spa and related facilities (bathrooms, equipment room, etc.) at least once a week to verify:
    a) That the pool or spa is in compliance with local codes
    b) That the pool or spa and its related facilities are maintained in a safe, clean, and orderly condition, and
    c) A broken, damaged, or malfunctioning fixture is promptly repaired or replaced

2. To be at a facility prior to opening (30 Minutes Prior to Opening) to measure, record, and adjust, if necessary:
    a) Disinfectant residual
    b) Combined chlorine level\
    c) pH
    d) Water clarity
    e) Water temperature
    f) Flow rate
    g) Filter influent and effluent pressures
    h) Pump Vacuum
    i) Drain covers, vacuum fittings covers, skimmer equalizer covers, and any other suction outlet covers are in place, secure, and unbroken
    j) Skimmer baskets, weirs, lids, flow adjusters, and suction outlet lines are free of any blockage
    k) Inlet and return covers or fittings are in place, secure, and unbroken
    l) Safety warning signs are in place around the pool or spa, including emergency instructions and phone numbers
    m) On/Off switches for pumps are clearly labeled and the location of the pumps is clearly identified

3. To be on-site or present according to the local jurisdictional code.

4. Measures and records, or supervises and verifies the measurement and recording, of the necessary information in the time frames specified: For most jurisdictions, the PSPO must test the **Chlorine and pH** in the water **every two hours for a main pool** and every **one hour for a spa or baby pool**. See the local Health Department codes for the information required. These records must be maintained on-site and available for **at least two years at the pool** and **three years total**.

5. To clean the filtration system when the filter pressure differential reaches a level specified by the equipment's manufacturer or as specified in the local codes.

6. Maintains disinfectant residuals according to the local codes.

7. Maintains water chemistry according to the local codes.

8. Shall ensure that:
    a) Additives and treatment chemicals are used according to manufacturers' instructions
    b) When chemicals are added directly to a pool or spa, no one is allowed in the water until the chemicals are dissolved and diffused throughout the pool or spa

9. Shall ensure that the water temperature for a heated public pool or spa does not exceed the local codes.

10. Shock the pool/spa according to the local codes.

11. Must close a pool or spa when:
    a) Residual disinfection levels are not within the required ranges
    b) Sanitary water quality has coliform bacteria levels within the acceptable ranges
    c) Water chemistry levels are not within the proper ranges
    d) When the water clarity is not acceptable according to local standards
    e) The recirculation or disinfection system is malfunctioning or not working
    f) When the protection of the public health, safety, or welfare imperatively requires emergency action.
    g) A lifeguard/PSPO is not present.

12. Sign and date all documents.

Welcome to the World of Management - The Swimming Pool Manager

Sometimes the operator and manager will be the same person. However, depending on the type of facility, the pool manager may be a different person with a completely different job description. Regardless, the pool operator on duty will provide leadership to their staff and ensure that each person that is working at the facility during their shift complies with the local health department code.

To create this safe and compliant environment, the pool operator or pool manager may be responsible for the training of pool personnel. In-service training is a vital part of any aquatic facility, and it is essential to document the type of training that facility staff participates in throughout the season.

When planning an in-service training program, be sure to include the following:

- CPR and First Aid
- Spinal injuries
- Lifeguarding skills
- Site-specific emergency action plan implementation
- Bloodborne pathogen training
- Site-specific rules, regulations, and activities (records and reports, job performance evaluations, orientations, scheduling, coaching, lessons, and special events)
- Hazardous areas of the facility
- Maintenance procedures

Aquatic facility managers and pool operators are not required by code to be certified lifeguards. Most individuals in these positions are not lifeguard instructors who are trained to present lifeguarding, CPR, and first aid instruction, nor are most trained to evaluate lifeguarding skills. Facilities and managers should seek the help of a professional company specializing in lifeguard training and/or in-service training to ensure adequate and effective in-service training sessions.

Those responsible for hiring staff need to be aware of the required certifications and validity of those certifications. Check with the local Health Department to find which lifeguard and CPR certifications are accepted. Most approved lifeguard training courses have a minimum age requirement of 15 to enroll in a class. While the minimum age is 15 to be a lifeguard, state child labor laws still apply and must be followed regarding the number of hours per week and length of shift.

According to the American Red Cross:

- Lifeguards must be a minimum of 15 years of age
- Lifeguards certified in LIFEGUARD TRAINING and FIRST AID are valid for two years.
- Lifeguards certified in CPR for the PROFESSIONAL RESCUER are valid for two years.

INJURY PREVENTION

A well–trained and attentive lifeguard is the most important safety equipment at an aquatic facility. Well-educated and well-informed patrons, along with strict enforcement of the rules and regulations, will make for a safe facility. A successful accident prevention program identifies cooperative responsibilities and roles for the entire staff and develops a team attitude. **PREVENTION** is the key to a safe facility.

Adult supervision is the best prevention of accidents at swimming pools.

Even the most vigilant staff cannot prevent all accidents. Most accidents do not occur in the water but instead on the deck or in the locker room. Within the pool, 95% of all diving accidents happen in shallow water (5 feet or less). Therefore, pools must have proper depth markings and that pool operators maintain appropriate water levels at their facility. The pool operator should regularly check the depth markings to be sure they are visible to ALL patrons.

Drowning is the second leading cause of death in children under the age of thirteen. There is often no warning to this catastrophic event as it happens quickly and even under the best conditions. AT NO TIME SHOULD ANYONE SWIM ALONE!!! At a single lifeguard facility, if the guard must leave the pool unattended for any reason, the pool MUST BE CLEARED. All swimmers must always be supervised!! Supervisors need to ensure the guard staff is alert and paying attention to the pool. Alcohol use should never be allowed in an aquatic facility. Alcohol/drug use is a frequent cause of drowning. Also, breath-holding activities should be discouraged.

According to the National Aquatic Safety Company, some facts that pool operators and lifeguard staffs should be aware of:

- Most rescues of active drowning victims happen in less than four feet of water to victims that are less than four feet tall and under the age of seven. (Shallow water does not mean safe water!)
- Twenty-five percent of all non-breathing victims are found in less than three feet of water and are under three years of age. (Lifeguards must monitor the baby pool!)
- Most drownings at facilities where lifeguards are present occur less than six feet from where the lifeguard is sitting. (Lifeguards must have a pronounced downward head swing as part of their zone scan. The lifeguard must look under their lifeguard chair.)
- One in every 142,000 pool visitors will die at the pool.

Local Health Department regulations may give specific regulations in the area of accident prevention. Be familiar with the local codes governing the following areas: Depth markings, Diving board rules and regulations, Illumination, Barriers, required safety equipment, First Aid supplies, lifeguard requirements, and Lifeguard/PSPO's "on-duty" requirements. At a minimum, the PSPO needs to ban the use of glass on the deck, educate patron on pool safety, conduct daily visual inspections, and supervise the safety staff.

REQUIRED RESCUE EQUIPMENT

All facilities must have the following rescue equipment:

1) Rescue tubes
2) Reaching poles,
3) Ring buoys and throwing lines,
4) Backboards, 5) First aid kits,
5) Emergency alert systems,
6) Emergency phones with current numbers posted, and
7) Resuscitation equipment

EMERGENCY ACTION PLANS

Because there are so many opportunities for accidents to occur at swimming pools, all staff must be aware of their responsibilities should an emergency arise. Regular review and actual practice of the Emergency Action Plan (EAP) is critical. **An EAP is a step-by-step plan to handle an emergency.** Each staff member should know what to do and where to go in the event of an emergency. Most lifeguarding program curriculum stresses the EAP, and all guards should be familiar with this; however, every facility is different, and each emergency action plan needs to be evaluated and practiced regularly.

The EAP should be specific and posted in clear view. At single lifeguard facilities, the EAP must be in patron view in case assistance is needed.

When developing an **EMERGENCY ACTION PLAN (EAP)**, use the following information as a guideline:

- Clear the pool – designate an area for patrons to remain during an emergency and staff to supervise.
- The primary rescuer is "in charge" during the emergency until a supervisor or EMT arrives.
- A designated staff member (desk attendant) calls 911 and collects the necessary information.
- Check with the responding Fire Company as to how they want spinal injuries handled.
- Check with the pool insurance company to find out what kind of information or record keeping they need when an accident occurs.
- If an adult is injured and needs medical attention, yet refuses, call an ambulance and let the EMT's handle the situation. This action will take the liability off the facility. If the adult is unconscious, consent is assumed.
- If a minor is injured, parental consent is needed to treat the child. If the injury is life-threatening and the parent is not around, consent is assumed. If a parent refuses treatment for their child, life-threatening or not, you CANNOT treat the child. Call an ambulance and let the EMT's handle the situation.

INCIDENT / ACCIDENT REPORTS

Should an accident occur, once the incident is over and all victims are treated, the responding staff needs to fill out all necessary paperwork. This should include but is not limited to, an accident report. Be sure to consult all those involved in the care of the victim and interview all witnesses. There should be a separate accident report for the aquatic department from the rest of the facility, as the pool/spa area presents many different risks of injury than other areas (i.e., the fitness area).

The following information should be considered when putting together an aquatic facility **Incident & Accident Report.**

- Injured person's personal information
- Date and time of the incident
- Witness names and addresses
- Type of injury – Do not guess as to the victim's injury and simply state the facts
- Location of the accident within the facility
- Type of rescue or assistance performed
- EMS called and what support they gave
- Name of the emergency facility and if the personal physician was notified
- Names of all staff members on duty
- Pool and weather conditions
- Any other information required by the pool insurance Company

POOL RULES

Adherence to pool regulations may significantly reduce the number of injuries in a pool facility. Rules should be posted at the entrance of the pool, and staff should have the authority to remove anyone who does not follow the rules. The following regulations are minimal standards to increase pool area safety and should be included along with the facility house rules.

The following is not an exhaustive list of rules:

- All patrons must take a cleansing soap shower before entering the pool area.
- Swimming is only permitted when a lifeguard is on duty and in the appropriate position
- Pool users must wear swimming suits or trunks upon entry to the pool. Clothing such as cut-offs, gym shorts, and underwear is not permitted in the pool.
- NO ONE is allowed in the pool with open cuts, sores, rashes, or bandages (consider having all band-aids removed before entering the pool)
- Glass containers, alcoholic beverages, drugs, and pets are not permitted in the pool enclosure.
- No running, pushing, or rough play is allowed in the pool or pool area
- No diving in less than 6 feet of water (or according to your health department code)
- Only 1 bounce and 1 person on the diving board at once
- Prolonged underwater swims for distance or breath-holding games are not permitted for safety reasons.
- Non-swimmers must remain in shallow water (chest deep or less).
- Children must complete a swimming test to swim unchaperoned in the water. Any non-swimming individual under the age of 12 needs to be under the supervision of an adult that is in approved swimming attire and preferably within arm-reach of the child.
- Spitting, spouting of water, blowing of the nose or urinating in the pool is prohibited
- Non-toilet trained individuals must wear a clean diaper covered by separate vinyl or rubber pants with elastic around the legs or waste. These pants must be worn regardless of the type of diaper.
- Any adult or child who is experiencing even a mild case of diarrhea may not use the pool.
- The use of cameras, video cameras, or any device containing camera equipment of any kind is prohibited in all locker rooms, bathrooms, and changing facilities.

The following pages are samples of incident accident reports, emergency action plans, pool rules and job descriptions:

EMERGENCY ACTION PLAN

Assess Situation

Life Threatening/Non-Life Threatening

Clear Swimming Pool or Emergency Area

Primary Rescuer Responds to Emergency Call 911(if necessary)

Alert Additional Staff

Provide Appropriate Emergency Response

Administer First Aid WhereAppropriate

Assign Individual To Meet EMS At Emergency Door

Complete Incident/Accident Report

Meet With Staff To Debrief Situation

Contact Insurance Company

Aquatic Training & Consulting Services
448 W South Street
Frederick, MD 21701
301-760-7114
info@aquatictrainingservice.com

Address____

Incident/ Accident

___Accident_______Incident

Staff on duty

Type of violation (If any)

____

. __________________________________

___ Pool and health club regulation
___ Health department regulation
___ General safety
___ Other
___

Authorized patron YES NO

Was this person's pool privilege suspended YES NO

Was 911 called YES NO

Length of suspension____

Person(s) Involved/ Injured

Name	Age	Name of parent if person is a minor
Address		Telephone

Name	Age	Name of parent if person is a minor
Address		Telephone

Incident/ Accident Description

Date and time
Location (Health Club, Indoor Pool, Jacuzzi, Etc.)
Description of Incident/ Accident
Was this person taken to the hospital Which one

Person(s) notified/ witnesses

Witness	Address	Telephone
Witness	Address	Telephone
Witness	Address	Telephone

Office Use

Insurance company notified	Date	By
Follow up/ deposition		

POOL RULES

All patrons must shower before entering the pool.

Children under the age of 13 must be accompanied by an adult.

Glass containers, alcoholic beverages, drugs and pets are not permitted in the pool complex.

Urinating, discharging fecal matter or blowing your nose is prohibited.

No food or beverages in the pool area.

No smoking.

The use of cameras, video cameras or any device containing camera equipment of any kind is prohibited in all locker rooms, bathrooms and changing facilities.

Diving is only permitted in designated areas.

No running or rough play permitted.

Any adult or child who is experiencing even a mild case of diarrhea may not use the pool.

Swim at your own risk.

EMERGENCY SCRIPT

FOR EMERGENCY USE ONLY

DIAL 911

"An aquatic emergency exists at the Frederick Community Swimming pool. The address of the facility is 448 W South Street, Frederick, MD. There is an Emergency Gate at the rear of the swimming facility. The ambulance can access the gate at the end of the parking lot. Someone will meet you there and direct you to the pool.

There has apparently been a ______________________________ injury."

Remain on the phone with the dispatcher until EMS arrives.

Do Not Hang Up

CHAPTER TWO

Water Balance

Water Chemistry & the Saturation Index

Chapter Objectives

1. Identify the five factors of water balance in swimming pools.
2. Learn the use(s) of the following: Muriatic Acid, Sodium Carbonate (soda ash), Sodium Bicarbonate (baking soda), Calcium Chloride, Sodium Bisulfate, Carbon Dioxide, and Sequestering agent.
3. Learn the purpose of a saturation index, how to calculate the index, and how to make proper adjustments to the swimming pool water.
4. Identify long-term problems that can develop when the following factors are permitted to remain too high or too low for extended periods.
5. List some problems that can develop with a high TDS level.

References used to collect the information presented in this chapter:

Reference 1: Hydrotech Chemical Corporation, "The Proper Management of Pool and Spa Water" by Kirk Mitchell
Reference 2: DIN 643, Treatment and Disinfection of swimming Pool and Bathing Pool Water.
Reference 3: NSPI, Basic Pool, and Spa Technology, 2nd Edition.
Reference 4: Chemical Automation Technologies, Inc., Cullin Tate
Reference 5: Swimming Pool Operation, The Washington State Public Health Association
Reference 6: APSP Professional Pool and Spa Operator: Basic Operator Manual Edition 1
Reference 7: Montgomery County Recreational Department Pool Operator Materials
Reference 8: MSU Education Resource Materials: Chapters 1 to 10

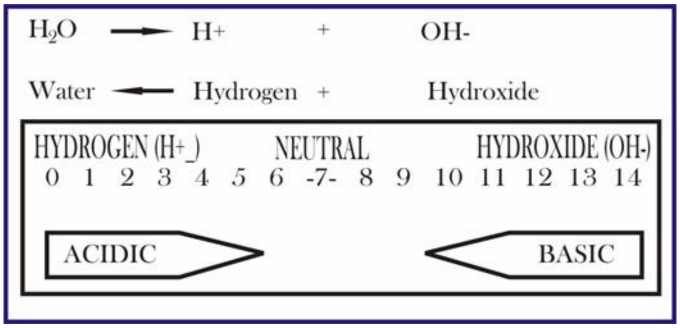
WATER BALANCE

The saturation index is a numerical figure that indicates water equilibrium or water balance. Five factors generally figure into water balance. **These factors are pH, Total Alkalinity, Calcium Hardness, Temperature, and Total Dissolved Solids.** All areas of water balance must be maintained for the pool to maintain its refreshing and sanitary qualities. Please note that while Chlorine may influence some of these factors, it is not part of water balance or the saturation index. Chlorine is the disinfectant in the water

A professional swimming pool operator's failure to maintain correct water balance will result in corrosive or scaling conditions in the pool and circulation system. When water balance factors are out of range for too long, the water can develop these tendencies. **Corrosive water** seeks to satisfy its hunger by dissolving virtually everything it contacts. It attacks metals, like iron and copper, and especially plaster surfaces. On the other hand, scaling water has too many ingredients. **Scaling water** seeks to relieve its overfed condition by releasing precipitates either as scale, cloudiness, or residue. It continues to deposit this excess until it reaches that "just satisfied" or "balanced" condition.

pH: The most important aspect of balanced water

pH is the measure of how acidic or how basic a solution is. It is a function of the hydrogen ion and hydroxide ion concentration and is defined as the negative log of the hydrogen ion concentration in a solution. The term pH is derived from the Latin words potens hydrogen meaning hydrogen power.



pH is measured on a logarithmic scale from 0-14. If the concentration of hydrogen ion (H+) is equal to the level of hydroxide ion (OH-), then the solution has a pH value of 7 and is termed neutral. A neutral solution is neither an acid nor a base. Distilled water (H20) has a pH of 7.0. If there is a higher concentration of hydroxide ions than hydrogen ions, then the pH value is more than 7.0, and the pH is basic. If there is a lower concentration of hydroxide ions than hydrogen ions, then the pH value is less than 7.0 and the pH is acidic.

It is the goal of the pool operator to create bather comfort. The best way to achieve bather comfort is to emulate the chemistry of the human body. **The pH of the human eye is around 7.5. Therefore the professional swimming pool operator's pH goal is 7.5**. This reading will also increase the effectiveness of the water's disinfectant. The pool operator should realize that everything that enters the pool will have some effect on the pH reading, and therefore, fluctuation will occur regularly.

For patron comfort and proper disinfection of the water, the acceptable pH value is between 7.2 and 7.8. However, the ideal range is 7.4 and 7.6, with a goal of 7.5.

Most local Health Departments' regulation for pH is 7.2 to 7.8, and it must be tested every two hours in a main pool and every one hour in a spa.

The pH value is tested with Phenol Red (R-004), usually in the large comparator tube of the facility's test kit. When the pH reading is outside of the ideal range, adjustments should be made.

Refer to the Chemical Safety Chapter in this book and the manufacturer's directions for the proper procedure for adding chemicals. When chemical adjustments are made always wear personal protective equipment, chemicals must be added to water (never water to chemicals), and never put chemicals directly into skimmers unless the manufacturer specifies this method in the directions. Material Safety Data Sheets will give additional chemical information and should be present.

If the pH of water is either in the acidic or basic range for too long, problems can start to develop. These are long-range problems that can have serious effects on the pool surface and equipment as well as water quality. To adjust pH, the pool operator should use one of the following methods:

If pH is too high and needs to be lowered, add one of the following chemicals:

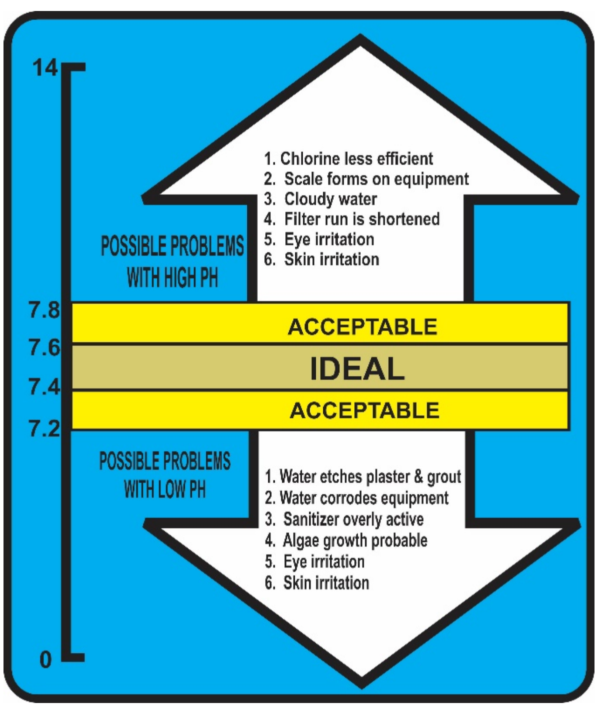
1. **MURIATIC ACID**: is poured around the perimeter of the pool or added through an automatic feeder. Muriatic Acid can be diluted in water. Muriatic Acid is hazardous, and personal protective equipment should be worn! Muriatic acid cannot be mixed with liquid or dry chlorine. Dosage for Muriatic Acid is approximately 12 oz per 10,000 gallons to decrease pH by 0.2 units.

2. **SODIUM BISULFATE**: (dry acid) can be used in the same manner as Muriatic acid. Dissolve it in water according to the manufacturer's recommendation. Dosage for Sodium Bisulfate is approximately 1 lb. per 10,000 gallons to decrease pH by 0.2 units.

3. **CARBON DIOXIDE**: is fed from a CO2 tank and requires a particular set-up. However, it is not corrosive and is safe if it springs a leak. CO2 breaks down into carbonates and bicarbonates, which helps maintain alkalinity in the proper range but will eventually cause the Total Alkalinity to rise outside of the recommended ranges.

If the pH is too low and needs to be raised, add:

SODIUM CARBONATE (Soda Ash): mix in water and pour the mixture around the perimeter of the pool. Dosage for Soda Ash is approximately 6 oz. per 10,000 gallons to increase pH by 0.2 units.



CAUSES OF pH CHANGE

Chemicals	Gas Cl_2	Lowers pH
	NaOCl	Raises pH
	$Ca(Ocl)_2$	Raises pH
	LiOCl	Raises pH
	DiChlor	Nearly Neutral
	Trichlor	Lowers pH
	Bromine	Lowers pH

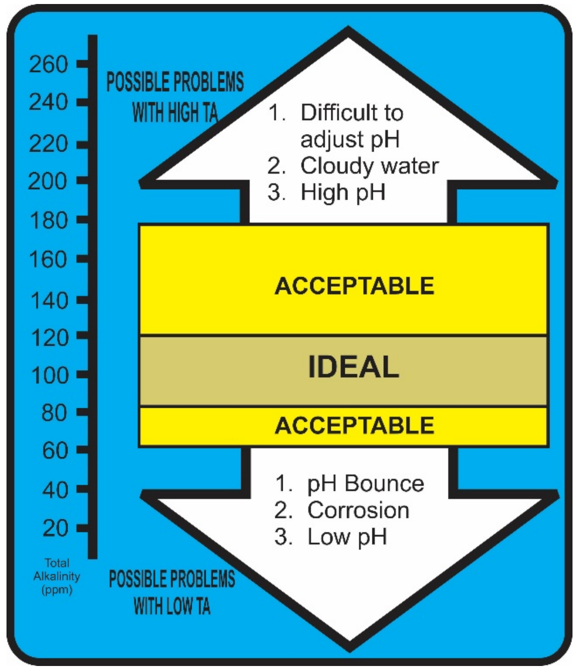
Make-up water
Rain, dust, pollen, and outside
pollutants Swimmers and their wastes
Fresh Plaster
Algae growth (absorbs CO_2 and raises pH)

TOTAL ALKALINITY

Total Alkalinity represents the number of carbonates, bicarbonates, and hydroxides in a solution. The form alkalinity will take (carbonate, bicarbonate, hydroxide) is a function of pH. In pH ranges of 7.0-7.9, the alkalinity is largely bicarbonate; from pH 7.9 to pH 8.9, the alkalinity is largely carbonate. (Reference 5, pg. 96)

Total Alkalinity is a measure of the pH-buffering capacity, or the ability of a solution to resist change in pH. (Reference 3, pg. 39) Buffering action is the resistance of pH to change in either direction. If the alkalinity is high, then it will be difficult to either raise or lower the pH; it resists change. **If the alkalinity is too low, wide fluctuations in the pH reading will occur. This is referred to as pH Bounce.** In these situations, the pH level will become so unpredictable that it may change as frequently as hour-to-hour. If the alkalinity is too high, the pH will be difficult to change, and the water may become cloudy.

For bather comfort and a stable pH, the acceptable alkalinity value recommended by ATCS is between 80 and 150 ppm. However, the ideal range is 80-120 ppm, with a goal usually around 100 ppm.



Most local Health Departments' regulation for acceptable Total Alkalinity is 60 to 180 ppm, and it must be tested once per week in a main pool and every day in a spa.

Refer to the Chemical Safety Chapter in this book and the manufacturer's directions for the proper procedure for adding chemicals. When chemical adjustments are made always wear personal protective equipment, chemicals must be added to water (never water to chemicals), and never put chemicals directly into skimmers unless the manufacturer specifies this method in the directions. Material Safety Data Sheets will give additional chemical information and should be present.

If the Total Alkalinity of water is, either, in the acidic or basic range for too long, problems can start to develop. These are long-range problems that can have serious effects on the pool surface and equipment as well as water quality. When the Total Alkalinity value is tested and found to be out of the ideal range, total alkalinity should be adjusted using one of the following methods:

If Total Alkalinity is too high and needs to be lowered, add:

MURIATIC ACID: pour directly over the main drain. This method is called "Hot Shot." and gives the maximum release of carbon dioxide (CO_2), and this is what you want to convert the bicarbonate ion to CO_2 and H20. Dilute in water and wear personal protective equipment. The dosage for Muriatic Acid is approximately 21 oz. per 10,000 gallons to decrease the Total Alkalinity by 10 ppm.

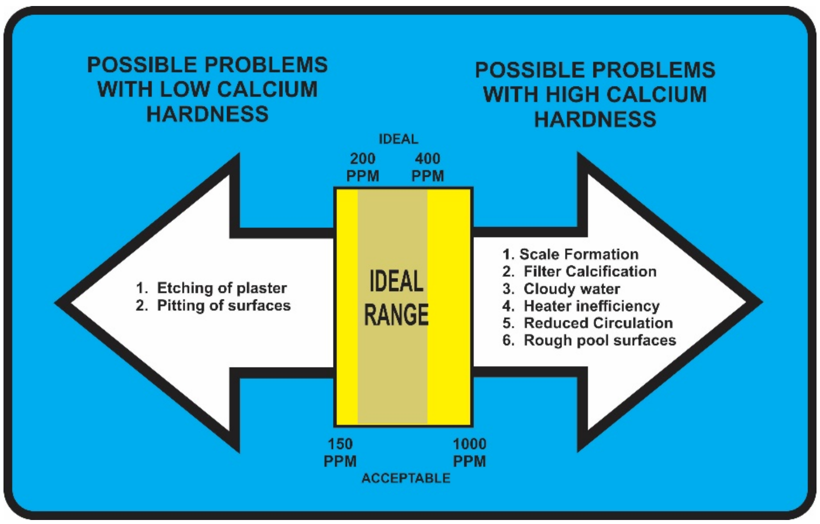
If Total Alkalinity is too low and needs to be raised, add:

SODIUM BICARBONATE (Baking Soda): mix into water and pour the mixture around the perimeter of the pool. Dosage for Sodium Bicarbonate is approximately 1.4 lbs. per 10,000 gallons to increase the Total Alkalinity by 10 ppm.

CALCIUM HARDNESS

Hardness is a measure of the mineral content of water. It is associated with several compounds, including calcium and magnesium carbonates, sulfates, chlorides, and nitrates, iron, and manganese compounds. (Reference 5, pg. 100) The most significant of these minerals to pools is calcium. Calcium is a natural component of water and is desirable to have the correct amount in your swimming pool water. Often Calcium is expressed in grains of hardness and therefore is discussed in terms of the water being too hard or soft.

When the water is too hard, it is usually due to the leaching process that occurs as surface and groundwater encounters rocks and soils containing Calcium and Magnesium. Hard water will produce scaling resulting in mineral deposits on the walls or in the pipes. A high mineral content may give water a green tint. Soft water is too low in hardness. Soft water readily foams and will cause corrosion. **Surface etching and pitting in the pool plaster will occur due to the increased solubility of calcium carbonate, which is the building block of plaster and marmite surfaces associated with pools and spas.** (Reference 1, pg. 34). Also, Corrosion can destroy metal parts due to the insoluble nature of calcium carbonate, which provides a film on metal surfaces, protecting them. As the temperature increases, calcium carbonate decreases. Spas need to have a slightly higher calcium hardness level, which will protect them and reduce foaming.



For patron comfort and maximum protection of the pool equipment and surfaces, the acceptable Calcium Hardness value recommended by ATCS is 150-400 ppm. However, the ideal range is 200-400 ppm.

Most local Health Departments' regulation for Calcium Hardness is 150 to 400 ppm, and it must be tested once per week for a main pool and every day for a spa.

Refer to the Chemical Safety Chapter in this book and the manufacturer's directions for proper procedure for adding chemicals. When chemical adjustments are made always wear personal protective equipment, chemicals must be added to water (never water to chemicals), and never put chemicals directly into skimmers unless the manufacturer specifies this method in the directions. Material Safety Data Sheets will give additional chemical information and should be present.

If the Calcium Hardness of water is either too high or too low for an extended period of time, problems can start to develop. These are long-range problems that can have serious effects on the pool surface and equipment as well as water quality. When the Calcium Hardness value is tested and found to be out of the IDEAL range, begin adding chemicals.

If Calcium Hardness is too high, do one of the following things:

1. The only acceptable method to lower the hardness level is to drain water from the pool and replace it with fresh water with a lower calcium level. Drain and fill only works if the replacement water has less calcium.

2. The use of a sequestering agent can hold calcium in suspension and prevent scaling but will not reduce the calcium level.

If Calcium Hardness is too low and needs to be raised, add:

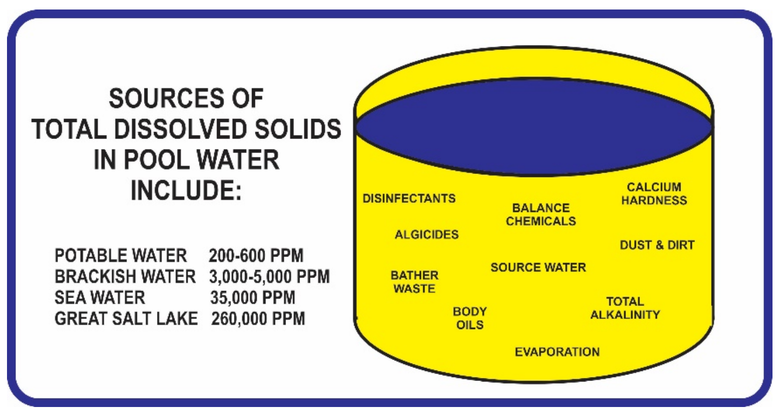
CALCIUM CHLORIDE: mix into lukewarm water before adding to the pool. Use small quantities and MIX WELL! Calcium chloride is an ice melt product; therefore, it will generate a significant amount of heat when mixed with water. Use extreme caution when using this chemical and never add chemicals to a pool when there are people in it. Dosage for Calcium Chloride is approximately 1.25 lbs. per 10,000 gallons to increase the Calcium Hardness by 10 ppm.

TOTAL DISSOLVED SOLIDS (TDS)

TDS is the sum of all soluble organic and inorganic materials dissolved in the water: minerals, salts, sweat, urine, etc. (Reference 1, pg.35). If all the pool's water were to be evaporated, the TDS would be the solids that are left. TDS is a semi-quantitative measurement of water's dissolved ion content and is derived by measuring the electrical conductivity of the water. As TDS increases (the number of the charged ions in the water increases), so does the build-up of un-oxidized or partially oxidized organic and nitrogenous contaminants from swimmer/soaker wastes and other sources. (Reference 1, pg.36) This matter cannot be eliminated with a chemical and continues to increase from disinfectants, water balance chemicals, clarifiers, algaecides, patron waste, and other pool debris.

TDS levels that are too high can cause:

1) Enhanced algae growth
2) Increase natural galvanic corrosion with a "high salt" content
3) Accelerate staining and scaling of pool and spa surfaces
4) Cloudy and dull-looking water
5) Foaming
6) Water balance is hard to maintain
7) Can reduce sanitizer efficiency by up to 50%



For patron safety and proper disinfection of the water, ATCS recommends TDS value is to be kept less than 1200 ppm. The TDS level will be higher in saltwater swimming pools.

Most local Health Departments' regulation for Total Dissolved Solids is 1500 ppm, and it must be tested every three months for an indoor pool. All indoor facilities are required to have a test kit for TDS.

If the TDS is too high:

The pool operator needs to drain and fill the swimming pool or spa to lower. There is not a chemical that reduces TDS.

Note: The DIN Standard (used in German public pool operation and in many other European countries), it is a formula for replacement of water daily. The formula is based on the number of bathers per day. Formula: Replace 7.9 gallons of water for each bather each day (Reference 2). For more information on the DIN Standard, refer to Chapter 7.

Over time, indoor pools tend to have more problems with TDS than seasonal (outdoor) pools and spas. This is because seasonal pools and well-kept spas are drained regularly enough that the TDS does not have an opportunity to get to high levels. High levels of TDS can cause galvanic corrosion that causes discoloration of the metals in the pool and circulation system. This is usually seen when the TDS level surpasses 2,000 ppm.

TEMPERATURE

The final factor involved in measuring water balance is temperature. Temperature affects the solubility of the chemicals. Most chemicals become more soluble when the water is warmer. The only exception to this is Calcium Carbonate which was mentioned earlier in this chapter. In outdoor pools, the temperature is often a variable that cannot be controlled by the operator. Regardless of the type of facility, the temperature is normally not a consideration for correcting water balance. Only at its extremes can temperature alone cause problems. Extreme high temperatures can cause scaling, and very low temperatures can cause corrosion.

Most heated pools are kept between 80 and 85 degrees. Compared to air, heat loss from swimmers may occur over 20 times faster in water. Hypothermia (the body being too cold) and/or heat emergencies can happen. Generally, the air temperature for an indoor facility should be about 5 degrees warmer than the water to prevent the body from becoming chilled. Most indoor pools that have a variety of activities choose to keep their water around 83 to 84 degrees, as this accommodates the most activities safely.

Most local Health Departments' regulations on maximum pool temperatures are:

Swimming Pool	**88 degrees**
Therapy Pool	**96 degrees**
Spa (Hot Tub)	**104 degrees**

THE SATURATION INDEX: "CHEMICAL EQUILIBRIUM"

The saturation index is the degree of saturation by calcium carbonate (CaC03) in the water. Calcium is the least soluble common mineral found in water and, therefore, the one that becomes aggressive or corrosive (to consume away gradually by chemical action). Oversaturated water will precipitate calcium carbonate and can cause scaling, resulting in rough surfaces and/or plugged pipes.

The five primary factors of the Saturation index formula are:

1. pH
2. Total Alkalinity
3. Calcium Hardness
4. TDS
5. Temperature

There are a variety of different Saturation indexes. Many different companies and organizations have developed their version of a Saturation index. The one presented in this book is the Langelier Saturation Index. W.L. Langelier developed it in 1936 at the University of California.

LANGELIER SATURATION INDEX.
pH + CF + AF + TF – 12.1
(12.1 is a constant for the TDS level less than 1000, use 12.2 for a level over 1000)

1. If the Saturation Index is 0, the water is (supposedly), perfectly balanced. (Reference1, pg. 37)
2. If the Saturation Index is a negative value, corrosion tendencies are indicated, causing damage to the plaster or grout by attacking or dissolving the calcium. (Reference 1, pg. 37)
3. If the Saturation Index is a positive value, scale-forming tendencies, or calcification are predicted. (Reference 1, pg. 37)

Values for the Saturation Index are considered acceptable if they fall between +0.5 and –0.5. A positive value is considered more acceptable than a negative index value in pool or spa applications. Pool operators should work, however, to keep this index between +0.3 to -0.3. MAHC recommends -0.3 to +0.5.

Most local Health Departments' regulation for the Saturation Index is +0.5 to –0.5, and it must be tested every week for a pool and every day for a spa.

Formula = pH + CF + AF + TF – 12.1

Calcium Hardness		Total Alkalinity		Temperature	
PPM	CF	PPM	AF	F	TF
5-24	0.3	5-24	0.7	32-26	0.0
25-49	1.0	25-49	1.4	37-45	0.1
50-74	1.3	50-74	1.7	46-52	0.2
75-99	1.5	75-99	1.9	53-59	0.3
100-140	1.6	100-149	2.0	60-65	0.4
150-199	1.8	150-199	2.2	66-75	0.5
200-299	1.9	200-299	2.3	76-83	0.6
300-399	2.1	300-399	2.5	84-93	0.7
400-799	2.2	400-799	2.6	94-104	0.8
800-999	2.5	800-999	2.9	105-127	0.9
1000 +	2.6	1000 +	3.0	128 +	1.0

USE THE CHART TO CALCULATE THE INDEX FOR THESE EXAMPLES:

Figure the saturation index for the following situations:

1. pH = 7.2 Alkalinity = 70 Calcium = 200 Temperature = 82

_________ + _________ + _________ + _________ = _________ - 12.1 = _________
pH CF AF TF TDS

Recommendations:

2. pH = 7.6 Alkalinity = 150 Calcium = 320 Temperature = 85

_________ + _________ + _________ + _________ = _________ - 12.1 = _________
pH CF AF TF TDS

Recommendations:

CHEMICAL ADJUSTMENTS

The following amounts are approximate; they may vary greatly depending on initial levels. Manufacturer directions should always be followed and should override these guidelines.

DOSAGES REQUIRED TO CHEMICALLY TREAT 10,000 GALLONS OF WATER

PARAMETER – CHEMICAL	REQUIRED DOSAGE
DECREASE PH	
Amount of Muriatic Acid to Change from 7.8 to 7.4	16 fluid oz.
INCREASE PH	
Amount of Soda Ash to Change pH for 7.0 to 7.4	12 oz.
DECREASE TOTAL ALKALINITY	
Muriatic Acid to reduce 10 ppm	1.6 pts.
Muriatic Acid to reduce 50 ppm	1.0 gallon
Muriatic Acid to reduce 100 ppm	2.0 gallons
INCREASE TOTA ALKALINITY	
Sodium Bicarbonate to increase 10 ppm	1.5 lbs.
Sodium Bicarbonate to increase 50 ppm	7.5 lbs.
Sodium Bicarbonate to increase 100 ppm	15 lbs.
INCREASE CALCIUM HARDNESS	
Calcium Chloride (100%) to increase 10 ppm	1 lb.
Calcium Chloride (100%) to increase 50 ppm	5 lbs.
Calcium Chloride (100%) to increase 100 ppm	10 lbs.

Calculate the following adjustments:
In 100,000-gallon pool how much sodium bicarbonate (baking soda) do you use to raise the total alkalinity from 75 to 100?

How much Calcium Chloride would you use in a 200,000-gallon pool to raise the Calcium Hardness from 150 to 200?

How much Muriatic Acid would you use to reduce the pH from 7.8 to 7.4 in a 50,000-gallon pool?

MEASURING WATER BALANCE

Water Chemistry & the Saturation Index

Chapter Review Quiz

Place the correct letter of the right-hand column that is associated with the item in the left-hand column.

___ 1. pH	A. The reagent used to measure pH
___ 2. Phenol Red	B. The acceptable range for pH
___ 3. 7.0	C. The acceptable range for Calcium Hardness
___ 4. 7.5	D. An acceptable range of water balance
___ 5. 7.2 to 7.8	E. Mineral deposits on the walls or in the pipes
___ 6. 60 to 180	F. Material Safety Data Sheets
___ 7. 150 to 400	G. The number of carbonates and bicarbonates in H2O
___ 8. Total Alkalinity	H. The measure of how acidic or basic the water is
___ 9. Low Alkalinity	I. Causes pH to bounce uncontrollably
___ 10. Calcium Hardness	J. Amount of Calcium and Magnesium in water
___ 11. Total Dissolved Solids	K. Neutral pH
___ 12. MSDS	L. All matter that cannot be eliminated with chemicals
___ 13. Too high of Alkalinity, pH or Hardness	M. Causes of Scaling
___ 14. Scaling is	N. Acceptable range for total alkalinity
___ 15. Too low pH, Alkalinity or Hardness	O. The pH of the human eye
___ 16. -.3 to +.5	P. Causes of corrosion

CHAPTER THREE

Preventing Disease Transmission

Chapter Objectives

1. Identify the relationship between microorganisms and pathogens.
2. Define the different types of diseases that can be transmitted through pools and spas.
3. List ways that facilities can prevent the transmission of disease.
4. Become familiar with the local fecal contamination and blood borne pathogen clean-up protocols.
5. Understand the OHSA regulations governing the aquatic industry.
6. Identify the four "right-to-know" requirements for aquatic employees.

References:
Reference 1: Hydrotech Chemical Corporation, "The Proper Management of Pool and Spa Water" by Kirk Mitchell.
Reference 5: Manual: Swimming Pool Operation, Washington State Public Health Association.
Reference: 6: "Clean water is Healthy Water", Aquatics International, September/October 1996, by Bonnie B. Sandel, Ph.D. See www.cdc.gov/healthyswimming

PREVENTION OF DISEASE TRANSMISSION

Disease transmission seldom occurs in swimming pools in the United States. Aquatic facilities that are maintained with an appropriate disinfectant like chlorine will eliminate the source of disease before infection can occur. In the rare circumstance that a pool does become the pathway for disease transmission, usually due to insufficient disinfectant levels at the facility, a pool should be considered the disease source if multiple patrons are affected with the same disease or show similar symptoms.

Microorganisms are microscopic plants or animals that cannot be eliminated from pool water. If they are disease-causing, they are called "pathogens". (Reference 5. Glossary) Microorganisms do not originate from the water; instead, they are brought into the swimming area by swimmers, clothing, leaves, toys, etc. It is the pool operator's responsibility to try to minimize the number of microorganisms present in the water by taking proactive measures to reduce the likelihood that they have entered the water (i.e. having patrons shower before entering) and providing and maintaining at least the minimum disinfection level.

SOME FACTS ON HOW MICROORGANISMS ENTER THE POOL:

- Up to 38,000 micro-organisms are discharged with the clearing of the nose.
- 100 million to 1 billion micro-organisms are discharged from 1 gram (1/3 of an ounce) of saliva.
- An active swimmer can contribute 1-2 pints of bodily fluids per hour. (To include perspiration, urine, saliva, nose discharge, etc.)
- Hands may shed ½ to 5 million organisms in a single washing.
- A person sheds a layer of dead skin each time they take a shower, get into a pool, etc.

Reprinted from reference 1, pg. 4

Our bodies depend on our immune system to kill most of the pathogens to which we are exposed. Many times, medicines, such as antibiotics, are used to aid our immune system in curing an infection.

There are six types of pathogens that can cause disease, called Disease-Causing Agents.

	Pathogen	Disease and Conditions, They Cause
1.	Viruses	Hepatitis, Measles, Mumps, Meningitis, Influenza, HIV
2.	Bacteria	Tetanus, Strep Throat, Tuberculosis, Food Poisoning
3.	Fungi	Athlete's Foot, Ringworm
4.	Protozoa	Malaria, Dysentery
5.	Rickettsia	Typhus, Rocky Mountain Spotted Fever
6.	Parasitic Worms	Anemia, Abdominal Pain, Respiratory/Cardiac Problems

The most common of these pathogens are Viruses and Bacteria.
Viruses are among the smallest of the infective microorganisms. The most well-known disease caused by a virus is the "common cold." Viruses may be transmitted by direct contact or may become airborne. Diseases caused by viruses are usually "self-limited," running their course and being killed by the body's defense system. Antibiotics do not kill viruses.

Bacteria, microscopic organisms, are present on the skin's surface of all individuals. Most bacteria are not harmful. Taking a shower can reduce the number of bacteria. However, the bacteria cannot be eliminated from the body. Showers are only effective in reducing bacteria if everyone takes a good shower with soap each time they enter the pool. Bacteria favor a warm, moist environment with an adequate food supply. (Reference 1, pg. 3)

Respiratory disease, sinusitis, strep throat, and intestinal disorders caused by amoebas and bacteria can all be transmitted through pools. Athlete's foot, dermatitis, and pink eye can also be spread.

"The most frequently reported outbreak in recreational water is dermatitis—itchy, sore, infected skin brought on by the use of a whirlpool or spa which is loaded with Pseudomonas aeruginosa bacteria." (Reference 6, pg. 1) **Pseudomonas** is a bacterium that thrives in warm waters. It is more prevalent in spas due to the warmer temperature; however, pseudomonas CAN be found in pools if the water temperature goes over about 89oF. It is essential during a very hot summer when the water temperature could approach or bypass 89oF, that the chlorine levels be kept higher. For more information on pseudomonas, refer to chapter 10.

HOW IS DISEASE TRANSMITTED?

Common infectious and chemical causes of RWIs, including but not limited to:
1) Diarrheal illness (Cryptosporidium, Giardia, Shigella, and norovirus);
2) Skin rashes (Pseudomonas aeruginosa, molluscum contagiosum virus);
3) Respiratory illness (Legionella);
4) Neurologic infections (echovirus, Naegleria);
5) Eye/ear illness (Pseudomonas aeruginosa, adenovirus, Acanthamoeba);
6) Hypersensitivity reactions (Mycobacterium avium complex, Pontiac fever, endotoxins); and
7) Health effects of chloramines and DBPS.

For a disease to be transmitted, the following four elements must be present:
1. A Pathogen must be present
2. There is enough of that pathogen present to cause a disease
3. A person must be susceptible to the pathogen
4. The pathogen passes through an entry site and into the body (Without each of these four criteria, infection cannot occur)

There are four ways for a pathogen to enter the body:
1. Direct Contact - touching another person's body fluids
2. Indirect Contact - touching a contaminated object

3. Airborne - inhaling infected droplets such as a sneeze or cough
4. Vector-borne - skin pierced by an infectious material (i.e., insect stings, animal bites)

HOW DOES THE AQUATIC STAFF PROTECT THEMSELVES FROM PATHOGENS?

There are 4 Universal Precautions you can take to protect yourself from disease transmission. These safe practices include:

1. Personal Hygiene
2. Personal Protective Equipment (basic precautions)
3. Work Practices
4. Equipment cleaning and disinfection

Personal Hygiene is the first step you can take to protect yourself from disease. Frequent hand washing is the easiest and most basic way to help prevent the transmission of disease. Do not wait until the threat of encountering blood or bodily fluid; get into the habit of making frequent hand-washing a consistent part of your work routine.

Personal protective equipment prevents direct or indirect contact from infected materials. This equipment includes the use of disposable latex gloves and the use of resuscitation masks (breathing barriers) when providing a victim with care. ATCS would like to make the following are recommendations:

- ALWAYS wear non-latex gloves when giving any type of care, no matter how minor
- After using gloves, remove and dispose of soiled materials properly
- Do not use punctured, torn, or discolored gloves
- After an emergency, do not handle any other items while wearing soiled gloves. Failure to do this could spread disease even further
- Keep all cuts, scrapes, or sores covered with appropriate bandages
- ALWAYS use a resuscitation mask when administering ventilations to a victim

Safe job practices will also contribute to protecting you in addition to personal hygiene and personal protective equipment. ATCS encourages pool staff to make sure that all the required protective equipment is at the job site. If there is any safety equipment missing or damaged, please inform the facility management.

Other practices that should be followed are:

- Place sharp items in containers that are puncture-resistant, leak-proof, and labeled
- Provide care that promotes containing an infected area as opposed to getting bodily fluids all over a large area
- Disinfect all contaminated work area and equipment
- Label and biohazard or contaminated materials and dispose of them properly

Any item or area that may have been contaminated during an emergency should be disinfected with a bleach or chlorine solution or disposed of in marked biohazard containers.

The recommended ratio of bleach or chlorine to water for disinfecting a contaminated area is:

1/4 cup of bleach/chlorine -- per 1 gallon of water

Anyone responsible for cleaning up after an emergency should protect themselves from contamination by wearing disposable non-latex gloves. Disposable gloves should never be reused, even if they have been disinfected.

Clean pool surfaces also help to reduce the number of places where microbes can breed and feed. Scrubbing visible surfaces, cleaning skimmers and traps, and attending to filter cleaning on a regular basis will result in more efficient use of sanitizing chemicals. (Reference 1, pg.2)

Appropriate Disinfection and Disease prevention begin with good sanitation. Always maintain proper sanitation levels.

Here are some other guidelines to follow:

- Require everyone to shower – with soap.
- Persons with open wounds, sores, rashes, and bandages are prohibited.
- Locker rooms (including floors, toilets, urinals, sinks, etc.) and decks are to be disinfected daily.
- Maintain proper water levels to ensure continuous skimming action and good circulation.
- During heavy use and /or extremely hot weather, raise chlorine residuals and super chlorinate regularly.
- Have water sampling for bacteria/organisms routinely completed by the Health Department

Prevention of disease transmission is one of the PSPO's primary duties. It relies on pool rules being enforced, disinfectant residuals remaining in the acceptable ranges, and the leadership skills of the PSPO.

> *"The last thing you want the public worrying about is how good their immune systems are, but with the list of possible waterborne diseases, it could be a valid question. How well you maintain your pool and spa can make the difference between a healthy, refreshing dip and a bath in a microbial soup." (Reference 6. p.1)*

> *"The most important thing the operator can do to ensure the health of people using the pools and spas is to maintain the proper residual of sanitizer in the water at all times…Because bacteria are constantly being added to the water from the environment and other bathers, a disinfectant must be present at all times. Chlorine gas and the hypochlorites are universally accepted for use in pools and spas because the chlorine supplied by chlorine-based sanitizers is the strongest oxidizer that persists in a pool. Most of the billions of bacteria that enter the pool with each dive are killed within 30 seconds, preventing bather-to-bather infections. Residual chlorine also kills pseudomonas entering from the environment, making dermatitis and ear infections unlikely."*

> *"Chlorine-based sanitizers are effective disinfectants that retain their ability to maintain water purity over weeks, months, and years of use, demonstrating that resistant strains of bacteria don't readily develop. This means that the bacteria which infect ears and open pores will not grow up in the pool this season –or next." (Reference 6, p.3)*

> *"Chlorine does kill all germs, but it takes time. A few germs can survive in chlorinated water for several hours to several days in pools, hot tubs, and spas, and you can, therefore, get infected. It is important to maintain proper levels of chlorine to kill germs. However, be aware that even the best-maintained pools can spread illness." (Reference 6, p. 5)*

All disinfecting systems take time to kill microorganisms. "Chlorine deactivates a variety of microorganisms at rates dependent on the species. Bacteria and viruses are destroyed within seconds, while the slower destruction times of cryptosporidium and giardia require special care in avoiding and taking care of fecal accidents."

Cryptosporidium, a microorganism, has become recognized as a frequent cause of waterborne disease in humans. The following is an excerpt from the State of Wisconsin's "cryptosporidium Fact Sheet for Swimming Pool Operators" (Wisconsin Health Department regulations, undated.)

> *"Cryptosporidium is a coccidian protozoan found mainly in fecal contaminated environments. One of these environments can be a swimming pool. The organism is transmitted through a fecal-oral route and resides in the intestinal tract. The infective dose can be very low as few as 10 organisms have been demonstrated to cause illness in animals. The illness caused by Cryptosporidium has an incubation period of 1-12 days with an average of about 7 days. The most common sign or symptom of illness is diarrhea, which is usually profuse and watery and often accompanied by abdominal cramping, malaise, fever, loss of appetite, nausea, and vomiting also can occur…"*

Cryptosporidium can also be transmitted through duck and geese feces. If your facility tends to draw ducks after the pool is filled, but before it opens for the season, be sure to superchlorinate the pool before allowing swimmers. (See chapter 4 for more information on shocking)

"Giardia is a germ that causes diarrhea. Giardia is found in infected people's stool and cannot be seen by the naked eye. This germ is protected by an outer shell that allows it to survive outside the body and in the environment for long periods of time." (Reference 6, p. 6)

Giardia and cryptosporidium can both be transmitted through recreational waters (including pools and spas). Swallowing the water or touching objects or surfaces that an infected person has touched can spread these diseases. Persons who swim while experiencing diarrhea and have a fecal accident can contaminate pools.

Germs that are rinsed off swimmer's bodies, including their anal areas, can contaminate pool and spas. In addition, lakes, rivers, and the ocean can be contaminated by sewage spills, animal waste, and water runoff. Diarrheal accidents are not easily noticed and, as a result, could contaminate even the best-maintained pool. Plus, some germs like Cryptosporidium are resistant to chlorine and can even live in pools with proper disinfection levels. (Reference6, p. 6)

Hyperchlorination may be necessary following a fecal or vomit release in an aquatic venue. Hyperchlorination is the intentional and specific raising of chlorine levels for a prolonged period of time to inactivate pathogens.

CT Inactivation Value represents the concentration of the disinfectant (C) multiplied by time in minutes (T) needed for the inactivation of a contaminant. The concentration and time are inversely proportional. The higher the concentration of the disinfectant, the shorter the contact time required for inactivation. The CT Value can vary with pH or temperature change so these values must also be supplied to allow comparison between values.

Check with the local Health Department regarding these policies.

CLEANING UP A FECAL ACCIDENT IN THE WATER:

- Clear the pool immediately.
- Clean the matter out of the pool. The feces can always be deposited in a toilet.
- Contact the local Health Department by phone.
- Communicate what type of accident has occurred, and the clean-up procedure that is being used.
- Refer to local regulations for specific procedures for clean-up.

CLEANING UP VOMIT IN THE WATER:

- Clear the pool immediately.
- Clean the matter out of the pool, following the local Health Department regulations regarding the clean-up.
- Close pool for at least 30 minutes, maintaining a chlorine level above 2.0 ppm.

CLEANING UP A BLOOD SPILL IN THE WATER:

- Clear the pool immediately.
- Follow the local Health Department regulations for handling this type of bodily fluid spill
- Close pool for at least 30 minutes, maintaining a chlorine level above 2.0 ppm.

CLEANING UP A BODILY FLUID SPILL ON THE DECK

- Block off the area as soon as possible to prevent patrons from walking through it.
- Use the bloodborne pathogen clean-up kit. At a minimum, this kit should contain protective equipment: face protection, gloves, an apron, and shoe covers, germicide or bactericide, red biohazard bags for disposal of all materials, a chemical that coagulates fluid spills, dustpan and brush, and paper towels or other absorbent cloths.
- With fecal or vomit, clean up the matter. Be sure to wear shoes, gloves, face protection, and an apron. Dispose of in an enclosed bag that is immediately tied and discarded. Facilities are to have a plan for the disposal of

biohazard bags. NEVER throw these bags into the regular trash. They must be disposed of at a facility where biohazard materials are accepted or picked up by a licensed company.

- Clean the area with a Clorox solution of 1/4 cup Clorox to 1 gallon of water. Store-bought clean-up kits usually contain a germicide already mixed, so either of these solutions is acceptable to use.
- Hose deck area thoroughly.

NOTE:
Hepatitis B and HIV are two diseases of concern when blood is involved. It is highly recommended that all lifeguards are vaccinated against Hepatitis B. One is more likely to contract Hepatitis B compared to HIV from a single drop of infected blood. Remember that HIV dies when blood dries, Hepatitis B does not. It can live for 7 days, maybe more, in dried blood. HIV and Hepatitis B are killed on contact with chlorine.

A NOTE ABOUT DIAPERS:

Swim diapers are unlikely to prevent diarrhea (which may contain germs) from leaking into the pool. Even though diapers (cloth diapers with snug-fitting plastic pants) or swim diapers may hold in some feces, they are not leakproof and can still contaminate the pool water. It is highly recommended that parents make frequent diaper checks and encourage children to use the bathroom often while swimming. Many jurisdictions have regulations regarding swimwear for non-toilet-trained children and or diaper changing, etc.

Most local Health Departments' regulation regarding swimwear for non-toilet-trained children is regardless of the type of diaper, rubber pants with elastic around the legs and waist must be work.

The following is an excerpt from "Prevention of Recreational Water Illnesses (RWIs)." Healthy swimming behaviors are needed to protect people from RWI's and will help stop germs from getting in the pool in the first place.

Here are six "P-L-E-As" that promote healthy swimming from healthyswimming.org:

Three "P-L-E-As" for EVERYONE
PLEASE don't swim when you have diarrhea…this is especially important for kids in diapers. You can spread germs into the water and make other people sick.

PLEASE don't swallow the pool water. In fact, try your best to avoid even having water get in your mouth.

PLEASE wash your hands with soap and water after using the toilet or after changing diapers. You can protect others by realizing that germs on your body end up in the water.

Three "P-L-E-As" for Parents with Young Kids
PLEASE take your kids on bathroom breaks often. Waiting to hear, "I have to go," may mean that it's too late.

PLEASE change diapers in a bathroom and not at the poolside. Germs can spread to surfaces and objects in and around the pool and spread disease.

PLEASE wash your child thoroughly (especially the rear end) with soap and water before swimming. We all have invisible amounts of fecal matter on our bottoms that could end up in the pool.

If all swimmers try to adhere to these guidelines, pools will be a much safer place to swim. Accidents are going to happen. There will be at least one fecal, vomit, and/or blood spill at almost every pool in a season, and at some facilities, there will be many. Be prepared!! Refresh emergency procedures often, and always keep the clean-up kits stocked and easily accessible. For questions on cleaning up bodily fluid spills, contact your local Health Department.

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

The U.S. Department of Labor, OSHA, governs many aspects of worker safety. One of those areas is the protection of workers against the transmission of disease.

The following information is reprinted from "Occupational Exposure to Bloodborne Pathogens: Precautions for Emergency Responders," a publication from the U.S. Department of Labor, Occupational Safety and Health Administration. OSHA 3130, 1992, (reprinted).

- OSHA recognizes the need for a regulation that prescribes safeguards to protect workers against the health hazards from exposure to blood and certain body fluids containing bloodborne pathogens and to reduce their risk of this exposure.
- OSHA's bloodborne pathogens standard requires the employer to prepare a written exposure control program.
- The standard applies to every employer with one or more employees who can reasonably be expected to come into contact with blood and other specified body fluids in performing their duties.
- Occupational exposure means a "reasonably anticipated skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious materials that may result from the performance of the employees' duties."
- A written exposure control plan is necessary for the safety and health of workers. Employees must develop a plan that identifies and documents the tasks, procedures, and job classifications covering instances where there is exposure to blood or other potentially infectious materials.
- As required under the standard, a written exposure plan is required that provides documentation of the following key elements.
  - Identification of job classification
  - A schedule of how and when the provisions of the standard will be implemented
  - Procedures for evaluating the circumstances of an exposure incident.
- All persons with a potential for exposure must be provided with adequate training and information, including general explanations of the modes of transmission, symptoms, epidemiology, warning signals relating to possible exposure, and procedures to follow if exposure occurs.
- Employers must make available, free of charge, and at a reasonable time and place, the Hepatitis B vaccine and vaccination series to all employees who are at risk of occupational exposure.
- Employees should immediately report exposure incidents. Employers must treat reports in strictest confidence. At the time of the exposure incident, the exposed employee must be directed to a health care professional.
- There are 2 types of employee-related records, required by the bloodborne pathogens standard: medical and training. The bloodborne pathogens standard also requires employers to maintain and to keep accurate training records for 3 years and to include the following:
  - Training dates
  - Content or a summary of the training
  - Names and qualifications of trainers(s), and
  - Names and job titles of trainees.

For a complete copy of this or any other free OSHA publication, contact them at:

U.S. Dept. of Labor
OSHA
200 Constitution Avenue Washington, DC 20210
1-202-693-1888
1-800-321-OSHA
www.osha.gov

EMPLOYEES HAVE THE RIGHT TO KNOW:

1. **<u>They may come in contact with blood and human waste.</u>**

2. **<u>They may come in contact with dangerous chemicals.</u>**

3. **<u>Personal Protective Equipment is provided by their employer.</u>**

4. **<u>Safety Data Sheets (Material Safety Data Sheets) are provided.</u>**

Employees have the right to:

- Access MSDS and CIL during the work shift, or within one day if away from the base site.
- Obtain a copy of MSDS or CIL at no charge within five days of the request.
- Receive training on chemical hazards.
- Be involved in decision-making and committees on health and safety.
- Refuse to work with a chemical if not provided the proper information.

Employees have the responsibility to:

- Know where to get information on hazardous chemicals used on the job.
- Learn to read and understand labels and MSDS and identify chemical hazards before starting a job.
- Ask questions.
- Use personal protective equipment and follow safe work practices.
- Follow the employer's procedures for disposal and clean up.
- Learn emergency procedures.
- Eat, drink, apply cosmetics or smoke away from hazardous chemicals

Water Disinfection

CHAPTER FOUR

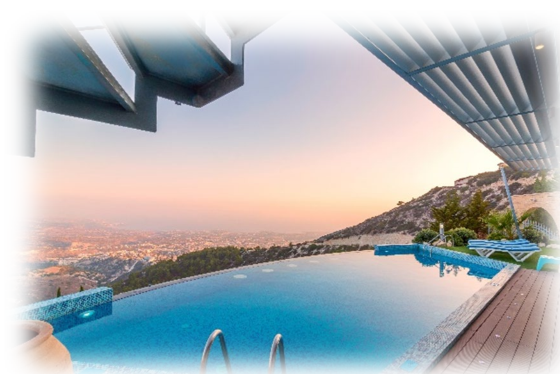
Chlorine and Other Methods of Disinfecting

Chapter Objectives

1. Identify why pools and spas need to be disinfected.
2. Understand the difference between stable and unstable chlorine.
3. Identify six different kinds of chlorine and their concentration levels and characteristics.
4. Identify the effect of all six types of chlorine on the pH reading.
5. Understand the difference between FAC (free available chlorine) and CAC (combined available chlorine).
6. Identify how to eliminate combined chlorine from the swimming pool through breakpoint chlorination and superchlorination.
7. Provide an explanation about the relationship between:
   a) pH and chlorine effectiveness
   b) Temperature and chlorine effectiveness
   c) Sunlight and chlorine effectiveness
   8. List other acceptable sanitizing methods used at swimming pools.
9. Understand the difference between hypochlorous and hypobromous acid.
10. Understand Bromine as an alternative disinfectant to Chlorine.

References:
Reference 1: Hydrotech chemical\ Corporation, "The Proper Management of Pool and Spa water" by Kirk Mitchell.
Reference 4: Chemical Automation technologies, Inc. Cullin Tate

WATER DISINFECTION



People like a pool that looks good. The bluish color comes from the light refraction on the water. That is why the deep end looks bluer than the shallow. Water that is poorly cared for can become cloudy or even turn green.

A pool that has been balanced according to the Saturation Index will be blue and look clear and inviting. Now it is time to add disinfection. Once people begin using the pool, disinfection becomes critical. A swimming pool is not the source of the disease, but rather the pathway of transmission if the disinfectant levels are NOT kept in the proper ranges as recommended by the local health department. The prevention of and subsequent elimination of the possible spread of disease is one of the PSPO's main jobs.

DISINFECTION - (Sanitize): The process of destroying living microorganisms and bacteria in sufficient numbers (by definition – 99.9%) to prevent the transmission of disease. (Reference 1)

DISINFECTANT – (Sanitizer): The chemical or device that kills or inactivates the microorganisms present in pool/spa water (Reference 4). The most common in the industry are chlorine and bromine

CHLORINE

Chlorine is the most common disinfectant used in the pool industry. Chlorine is a member of the Halogen family.

Halogen: Any element found in Group VII of the periodic table. Due to their great chemical reactivity, the halogens never occur free in nature. They must be prepared from their stable salt (i.e., sodium chloride [NaCl]). Chlorine (considered to be the best oxidizer and algaecide), bromine, and iodine are examples of halogens.

Chlorine is the best disinfectant in the Halogen family because it is the best **oxidizer**.

There are 6 types of commonly used chlorine, divided into 2 categories:

1. UNSTABILIZED (INORGANIC): These compounds **do not** contain carbon and are VERY sensitive to UV light. This means that when the sun comes out, the chlorine will dissipate (go away.) Unstabilized Chlorine includes Gas Chlorine, Sodium Hypochlorite, Calcium Hypochlorite, and Lithium Hypochlorite.

2. STABILIZED (ORGANIC): These compounds **do** contain carbon, usually in combination with elements such as hydrogen, oxygen, nitrogen, and sulfur. These are NOT sensitive to UV light. Stabilized chlorines include Trichloroisocyanuric Acid (Trichlor) and Dichloroisocyanuric Acid (Dichlor).

Unstabilized or Inorganic Chlorines are sensitive to the sun's UV rays. If Unstabilized or Inorganic chlorine is used in an outdoor pool, the addition of Cyanuric Acid will be necessary to stabilize it and prevent the loss of chlorine due to sunlight.

Organic or Stabilized chlorines already contain the CYA as part of their chemical make-up. While this property makes stabilized chlorine seem like an excellent choice for an outdoor pool, it is not because the cyanuric acid continues to rise and surpasses 100 ppm rendering the chlorine ineffective. Often in residential pools, this is not a concern because of the low use of the pool requires less chlorine to be added throughout the season.

STABILIZER

CYANURIC ACID (CYA): the chemical used to stabilize an outdoor pool. CYA is added directly through a skimmer after being thoroughly diluted in a bucket of water or kneaded through old hosiery (Note: This is one of the very few chemicals that should ever be added through a skimmer. Always add chemicals directly to the pool unless otherwise directed.)

To raise the CYA level, add Cyanuric Acid:
Add CYA slowly over the course of several days. Depending on the size of the pool, it may take quite a bit of CYA to get the pool "stabilized" in the beginning of the season.

{Dosage for Cyanuric Acid is approximately 3 lb per 10,000 gallons to increase 30 ppm}.

Put the Cyanuric Acid into the skimmers and add only a cup or so per skimmer per day until the desired level is reached. Be sure the pool has been recently backwashed (See Ch. 9 for information on backwashing) BEFORE adding the CYA. Most jurisdictions do not require daily testing because the level does not change that quickly. CYA will need to be added periodically throughout the summer. Wait 24-48 hours after each addition before adding more. This will ensure adequate circulation and re-testing to avoid overdosing.

Your local Health Department regulation for Cyanuric Acid (CYA) is 30 to 50 ppm, and it must be tested every week for a main pool.

When the CYA value is tested and found to be out of the range, begin adding the Cyanuric Acid as described above. Most jurisdictions are strict on the CYA levels. In some jurisdictions, the Chlorine level is based on the CYA level, and other factors will, at times, play into what the Health Department considers an acceptable level.

The pool operator should shoot for a reading of 50 ppm to maximize chlorine efficiency. As CYA levels go past 50, reduced stabilization occurs, and the effectiveness of the disinfectant decreases. **When the CYA level is above 100 ppm, no additional stabilization is obtained,** and reports have shown reduced disinfection and oxidation at elevated levels. (Reference 1, pg. 10) This sometimes is referred to as chlorine lock.

To Lower the CYA level, the pool must be partially drained and refilled with water that has less CYA. There is no chemical to lower the CYA level.

Many factors figure into which chlorine is best for a facility to use. Much is dependent on how the individual system is built and must be evaluated to determine what type of disinfectant system will work most efficiently and be the most cost-effective.

One of the most important factors to consider is Available Chlorine Content (ACC). ACC refers to the relative sanitizing and oxidizing strength of chlorine. (Reference 1, pg. 13) Chlorine with a higher ACC has more oxidizing potential. Chlorine gas (with its 100% ACC) is the reference compound for which other halogenated compounds are evaluated. (Reference 1, pg. 13)

	CHLORINE	ACC
1.	Gas	100%
2.	Sodium Hypochlorite	10-15%
3.	Calcium Hypochlorite	65-70%
4.	Lithium Hypochlorite	35%
5.	Tri-chlor	89%
6.	Di-chlor	62%

Below are the chemical reactions that occur when each of the chlorine compounds is introduced into the water (H20). With each reaction, HOCl (Hypochlorous Acid) is formed.

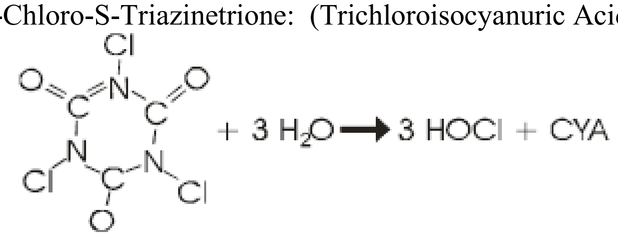
HYPOCHLOROUS ACID (HOCl): Is the primary chemical species responsible for the disinfection of pool water. It is the part of the chlorine, responsible for disinfection. Once the hypochlorous acid is formed, the remaining product determines the acidity or basicity of the product.

Unstabilized

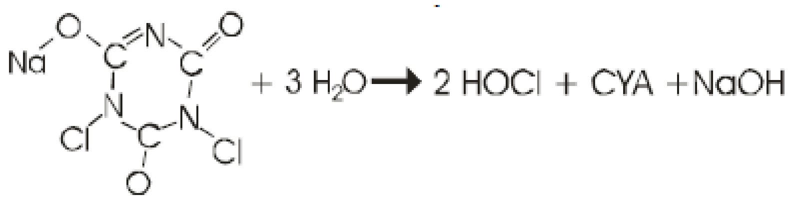
1.	Gas Chlorine: Cl2	Cl2 + H2O → HOCl + HCl
2.	Sodium Hypochlorite	NaOCl + H2O → HOCl + NaOH
3.	Calcium Hypochlorite	Ca(OCl)2 + 2H2O → HOCl + Ca(OH)
4.	Lithium Hypochlorite	LiOCl + H2O → HOCl + LiOH

Pre-stabilized

5. Tri-Chloro-S-Triazinetrione: (Trichloroisocyanuric Acid)



6. 6. Sodium Dichloro-S-Triazinetrione: (Sodium Dichloroisocyanuric Acid)



After the Hypochlorous acid is formed, what is left determines whether that chlorine is acidic or basic. For instance, with gas chlorine, HCl (hydrochloric (Muriatic) Acid) remains once the HOCl has formed. Since this is an acid, gas chlorine is acidic, and a base (Sodium Carbonate) will need to be added daily in order to keep the pH in the proper range.

Each type of chlorine has its own properties, advantages, and disadvantages for pool application. These will be discussed on the following pages.

1. GAS CHLORINE CL_2

Gas is an excellent sanitizer; however, due to its toxicity, it cannot be used in new pool construction. In some states, it may continue to be used if it is currently the source of disinfection for an existing facility. The gas is sold in steel tanks that are kept in a room separate from the rest of the circulation system. Gas is heavier than air and will sink in the event of a leak. **Therefore, this room must have ventilation at the floor level** and be able to exchange the air within 1-4 minutes.

A bottle of household ammonia is also required to be present where the gas tanks are being stored. When ammonia comes in contact with the gas in the event of a leak, a white mist is formed, identifying the leak. The tank that is presently being used will sit on a scale and is weighed daily. This is how the PSPO will know when the tank is almost empty. **The other tanks, not currently in use, must be chained to the wall to prevent tipping over.**

A self-contained breathing apparatus is also required. A person, preferably the PSPO, specially trained in the proper use of the self-contained breathing apparatus, must always be on site. Keep the self-contained breathing apparatus in operational order and OUT of the chlorine room.

It is important NOT to throw water on a chlorine gas leak. If water encounters a chlorine gas leak, hypochlorous acid is formed, which will increase corrosion and leakage. Careful handling of the equipment will help ensure safety and prevent leaks.

Gas chlorine has an extremely low pH. Straight hydrochloric acid is formed when it mixes with water. Therefore, Sodium Carbonate (Soda Ash) is needed daily to keep the pH in the proper range.

{It takes approximately 1.3 oz. of gas per 10,000 gallons of water to raise the free chlorine level 1 ppm.}

2. SODIUM HYPOCHLORITE: NAOCL (LIQUID CHLORINE)

Sodium Hypochlorite is one of the most widely used chlorines in the industry. This is most likely due to the ease of use and the low cost. Sodium is a thick, yellowish liquid. It is usually stored in large vats and is delivered by a tanker truck. This can be a disadvantage if the operator allows the level to get low or run out, and the delivery company is not able to get there immediately. (Always keep dry chlorine on hand, in case the liquid runs dry).

Sodium Hypochlorite, "bleach," comes in at an extremely high pH, around 14. Therefore the addition of muriatic acid is necessary daily to maintain pH in the proper range.

Sodium Hypochlorite is very unstable and loses its composition quickly. The hotter it is, the quicker it decomposes. It needs to be stored in a cool dark place. To ensure the quality of the bleach, order only a 1-month supply at a time.

In most systems, liquid chlorine is fed into the system via a chemical feeder. (See Appendix B, pg. 121 for the procedure on cleaning these types of feeders). Muriatic acid can also be fed through a similar type of feeder. Be extremely careful NOT to allow these feeders to get mixed up. **SODIUM HYPOCHLORITE and MURIATIC ACID DO NOT MIX!** They can cause the release of fatal gases and/or an explosion if they come in contact. Keep the containers well labeled, covered, and as far away from each other as possible.

3. CALCIUM HYPOCHLORITE: $CA(OCL)_2$

Calcium hypochlorite is a dry chlorine that comes either in granular or a tablet form. It can be dissolved in water to produce a liquid, although this is not recommended for daily disinfection. Calcium hypochlorite is very hard to dissolve. This property can be disadvantageous, especially for vinyl liners and pools with fresh plaster or paint. Dissolving it in lukewarm water will help.

The pH of calcium hypochlorite is around 11; therefore, the addition of muriatic acid will be needed daily to keep the pH in the proper range.

For many years, granular calcium hypochlorite was not very practical to use as the daily disinfectant due to its insolubility. However, the introduction of erosion feeders and calcium hypochlorite in a tablet or puck form has improved its practicality. The tablets are fed through an erosion feeder, which is plumbed into the circulation system. The tablets dissolve at a steady rate and provide a consistent chlorine residual until the stored chlorine is exhausted**. Be sure to use only compatible tablets or pucks according to the manufacturer's instructions.**

EROSION FEEDERS are enclosed apparatuses used to dispense disinfectants. Water flows through the feeder eroding the solids inside and sending the disinfected water into the system.

A possible disadvantage of calcium hypochlorite is that over time, it will raise the calcium hardness level in the pool. In areas with "soft" water, this is usually not a problem. If the fill water is "hard," this can be a disadvantage. Regular testing will allow the PSPO to monitor the Calcium Hardness level.

Calcium hypochlorite is an excellent choice to use for cleaning up bodily fluid spills and dealing with fecal contamination. See the local Health Department regulations for specific procedures in handling these spills and contaminations. This chlorine is the most commonly used disinfectant to superchlorinate the pool (superchlorination is covered later in this chapter).

{It takes approximately 2 oz. of Calcium Hypochlorite per 10,000 gallons of water to raise the free Chlorine level 1 ppm.}

4. LITHIUM HYPOCHLORITE: LIOCL

Lithium Hypochlorite is a granular chlorine. The main advantage of using Lithium over Calcium is that it is very soluble (it dissolves very quickly). The ACC is much lower than Calcium, but it is better for vinyl liners and freshly painted or plastered pools because of its solubility. Pound for pound, it is more expensive than calcium. This disinfectant is mainly used in residential swimming pools because of its solubility.

The pH of lithium hypochlorite is about 11; therefore, the addition of muriatic acid will be needed in order to keep the pH in the proper range.

{It takes approximately 3.8 oz. of Lithium Hypochlorite per 10,000 gallons of water to raise the free Chlorine level 1 ppm.}

5. TRICHLOROISOCYANURIC ACID: (TRICHLOR)

(PRE-STABILIZED CHLORINE)

Trichlor is a solid and is available in sizes ranging from 1” tabs to large sticks. Chemically, Tri-chlor breaks down into the hypochlorous acid ion, and cyanuric acid. Therefore, Trichlor is an excellent choice for an outdoor residential pool, but usually not a good choice for commercial outdoor pools. (Some jurisdictions do not allow Tri-chlor to be used in an indoor pool).

It has a very low solubility rate and therefore is excellent for erosion feeders, floaters, and skimmer use. (Skimmer use is NOT allowed at a commercial facility in most jurisdictions). The size of the erosion feeder (based on the size of the pool), determines the size of the tablets. Note: Be careful to reorder the appropriate size and always use the feeder exclusively designated for the brand being used (follow all manufacturer's recommendations).

Trichlor has a low pH (2.8-3.0). Therefore the addition of Sodium Carbonate (Soda Ash) is needed on a daily basis to keep the pH in the proper range.

{It takes approximately 1.5 oz. of Trichloro-s-triazetrione per 10,000 gallons of water to raise the free Chlorine level 1 ppm.}

6. SODIUM DICHLOROISOCYANURIC ACID (DICHLOR):

(PRE-STABILIZED CHLORINE)

Dichlor is granular chlorine, and it contains cyanuric acid. It is very soluble and is usually used by dissolving it in water, adding a little soda ash, and feeding it into the system with chemical feeders like those used to feed sodium hypochlorite.

The General mixing formula is as follows:

- 12 pounds of dichlor
- 1 ½ pounds soda ash
- 55 gallons of water

Fill a 55- gallon vat Â¾ full of water, mixing in the soda ash as it fills. All at once, pour in the dichlor, put the lid on, and allow to sir for about 10 minutes. Stir until completely dissolved (using a wooden handle, not metal) and fill the vat the rest of the way with water.

The pH of dichlor in the dry form is about 4.0. By adding the soda ash and water, the pH rises to 7.5. Since this is an ideal pH for pools, dichlor is an excellent choice for an outdoor facility. Minimal pH control is needed when using dichlor as a daily disinfectant.

There are many factors to consider when selecting a disinfectant for a swimming pool/spa.

- Is the pool indoor or outdoor?
- What are the chemical readings of the fill water?
- What is the water temperature going to be?
- What is a normal bather load?

Choose a disinfectant that meets the water quality needs as well as the financial constraints of the facility.

THE CHEMISTRY OF HYPOCHLOROUS AND HYPOBROMOUS ACID

Hypochlorous acid (HOCl) is the primary chemical species responsible for the disinfection of pools and spas. HOCl is very active. It destroys harmful organisms such as bacteria, algae, and fungi.

pH, temperature, and sunlight affect hypochlorous acid. As pH increases, chlorine's effectiveness decreases. As the temperature increases, chlorine's effectiveness decreases. As the amount of sunlight increases, HOCl ion breaks down, and the effectiveness of the chlorine decreases.

Chlorine breaks down into two species:

1. FAC - Free Available Chlorine
2. CAC - Combined Available Chlorine

The combination of these species is known as TAC – Total Available Chlorine

1. **FAC – Free Available Chlorine** is the sum of HOCl (hypochlorous acid) and OCl^- (hypochlorite anion). It is the species that disinfects the water. The hypochlorite anion has very little oxidizing potential and therefore is a very weak disinfectant and plays a very little part in disinfecting the water, so therefore is not of significant importance in this discussion.

   FAC is tested by using DPD #1 and #2 drops OR a DPD #1 tablet.

Most local Health Departments' regulation for FAC is 1.0 to 10 for a main pool when not using CYA, 3.0 to 10 ppm for a wading pool (baby pool), and 4.0 to 10 ppm for a spa. It must be tested every two hours for a main pool and every hour for wading pools and/or spas. The minimum FAC increases to 2.0 ppm when CYA is being used.

2. **CAC – Combined Available Chlorine** is readily combined with free available chlorine with ammonia and nitrogen compounds. This formation is called a chloramine. Chloramines are chlorine/ammonia compounds. They are more stable than free chlorine but are not as effective as a disinfectant. Chloramines can cause eye irritation, skin rashes, and an irritating odor especially noticed in indoor pools.

   Adding DPD #3 drops or a DPD #3 tablet to the FAC sample will give the TAC in the pool. If the sample turns a darker shade of pink, this indicates the presence of combined chlorine—the darker the sample, the more combined chlorine that is in the pool. The CAC is found by subtracting the FAC from the TAC. See the test kit directions for specific procedures.

Most local Health Department regulation for CAC is 0.4 ppm and it must be tested when the FAC is tested.

3. **TAC – Total Available Chlorine** is the combination of free and combined chlorine.

   TAC= FAC + CAC

SUPERCHLORINATION (SHOCKING)

Shocking is a general term referring to the removal of materials that have a chlorine demand, organic and inorganic contaminants.

CHLORINE DEMAND: The amount of chlorine needed to react with substances in the pool. The more swimmers use the pool, the higher the chlorine demand. In outdoor pools, direct sunlight, aeration, organic debris, and increased bathing load increase chlorine demand. Bathers, sweat, body oils, etc. increase indoor pool demand.

Several reasons why a pool might need to be shocked:

a) After a thunderstorm (outdoor pools)
b) Beginning or end of the season
c) After a fecal, blood, or vomit spill
d) After a period of heavy usage
e) When the CAC level is too high
f) When the water is cloudy

METHODS FOR SHOCKING A POOL OR SPA

a) **Breakpoint Chlorination**

To achieve breakpoint, you must add 10 times the CAC level in additional free chlorine. The idea is to add enough chlorine so all organic (ammonia/nitrogen) compounds are joined with a FAC and then they burn off into the atmosphere. The CAC will increase at first that's why it is so important to add enough chlorine to actually "reach breakpoint."

EXAMPLE 1:

Free Available Chlorine:	DPD 1&2	=	3.0 ppm
Total Available Chlorine:	DPD 1, 2, & 3	=	4.0 ppm
Combine Available Chlorine	TAC – FAC	=	1.0 ppm

The CAC is greater than 0.4, so Breakpoint must be achieved.

Breakpoint Chlorination:	FAC + (10 x CAC)		
Breakpoint Chlorination:	3.0 + (10 x 1)	=	13 ppm

This means that enough chlorine must be added to the pool to equal 10 ppm of additional chlorine. The amount of chlorine that needs to be added is dependent on the number of gallons that the pool holds, and the ACC of the chlorine being used. See the manufactures directions for chlorine amounts.

Breakpoint is the process of adding enough chlorine to chemically convert chloramines to inert nitrogen gas. Adding less than the required amount will not only "not achieve breakpoint" but may actually increase it. When the pool reaches breakpoint, a sudden drop in residual is noted. (The term residual is sometimes used in place of the term "reading" or "level.")

b) **Superchlorination**

Adding larger than normal doses of chlorine. At least 10-15 ppm of additional chlorine must be added for it to be superchlorinating. Superchlorinating for algae removal is up to 30 ppm. The practice of periodic superchlorination is an attempt to pass breakpoint and rid the pool/spa of the accumulation of CAC and chlorine demand compounds. The addition of HOCl is needed to oxidize organic compounds and CAC. This procedure is commonly used for clean-up of blood, vomit, and/or blood spills. Superchlorination can cause some additional problems if procedures are not carefully monitored. Superchlorination can produce the following negative effects:

- a) Upset water balance
- b) The pool will have to be closed for several hours, at least
- c) Dry skin, discolor dyed hair, and bleach bathing suits

Excessively high chlorine levels can cause the following:

- a) bather discomfort
- b) DPD "Bleach out" (see Ch. 6)
- c) Inaccurate pH readings (see Ch. 6)

EXAMPLE 2:

Free Available Chlorine:	DPD 1&2	=	2.5 ppm
Total Available Chlorine:	DPD 1, 2, & 3	=	3.0 ppm
Combine Available Chlorine	TAC – FAC	=	0.5 ppm

The CAC is greater than 0.4. so Breakpoint must be achieved.

Breakpoint Chlorination:	FAC + (10 x CAC)		
Breakpoint Chlorination:	2.5 + (10 x 0.5) =		7.5 ppm

To Superchlorinate the Pool Operator Raises the FAC by 10 ppm

The Remaining FAC the next day will be:	12.5 - 7.5	=	5.0 ppm

Swimmers should not be allowed in the water if the FAC exceeds 10 ppm! Once the chlorine level is higher than the local Health Department regulation allows, no swimmers may enter the water until the level is brought down to an acceptable level.

c) Hyperchlorination

This is the intentional and specific raising of chlorine levels for a prolonged period of time to inactivate pathogens following a fecal or vomit release in an aquatic venue. Hyperchlorination is accomplished by:

1) Following the preparatory guidance outlined in MAHC 6.5.2.3;
2) Lowering the CYA concentration to less than or equal to 15 ppm by draining, if necessary;
3) Raising the FREE CHLORINE RESIDUAL to 20 mg/L for at least 28 hours; 30 mg/L for at least 18 hours; or 40 mg/L for at least 8.5 hours, which is needed to reach the CT INACTIVATION VALUE; and
4) Measuring the inactivation time required, which shall start when the AQUATIC VENUE reaches the intended FREE CHLORINE RESIDUAL level

If hyperchlorination cannot be achieved, the operator can use a secondary disinfection system or drain the pool.

Sodium Thiosulfate (AKA de-chlor) is a chemical that will REDUCE sanitizer levels. Please note that while Breakpoint Chlorination does lower the FAC when achieved, if there is no combined chlorine present, adding more chlorine will only make the FAC continue to rise

{Sodium Thiosulfate is used at a rate of 1 oz. Per 10,000 gallons to reduce 1 ppm, and ½ oz. per 10,000 gallons will reduce bromine 1 ppm.}

d) Persulfate oxidation (Non-Chlorine shock)
A chlorine-free shock treatment is an effective oxygen-releasing agent. It can be routinely used as a general shocking compound, mostly for the elimination of chloramines. These compounds directly oxidize waste. Persulfate reacts directly with combined chlorine and organic wastes to destroy them. Persulfate is safe in the water, and once it has dispersed, the pool or spa can be reopened in about 15 minutes.

{Non-chlorine shock treatments are generally used at a rate of 1 lb. Per 10,000 gallons}

BROMINE

Bromine is another acceptable disinfectant used in swimming pools/spas. Also, a member of the halogen family (see p.35 for definition) it offers some excellent disinfectant properties. Bromine is available in 3 forms.

1. Elemental Bromine: Br_2
   In its elemental form, bromine is a heavy, reddish-brown liquid whose use has been discontinued in the United States and Canada. It is still used in Europe because of its excellent disinfectant qualities. Those who use it are specially trained in its proper use.

Br2	+	H_2O	=	HOBr	+	HBr
Elemental Bromine		Water		Hypobromous Acid		Hypobromic Acid

2. Bromo-3-Chloro-5.5- Dimethylhydantoin (BCDMH)

   Bromine tablets, (1" in diameter) are dissolved in an erosion feeder. Dissolving bromine tabs in water results in hydrolysis of BCDMH. It breaks into hypochlorous and hypobromous acids. Though bromine sticks produce both hypobromous and hypochlorous acid, its oxidizing potential is less than that of chlorine. For this reason, a chlorine-based shock is good to use when using bromine. Before entering the water, the pH is 2.0-6.0. When bromine enters the water, it buffers out and has a pH around 7.2-7.3. So technically, bromine is acidic.

3. Sodium Bromide/Monopotassium Persulfate
   NaBr KHS0_3
   This is a 2-part system usually used for spas. Sodium bromide is a salt with no disinfecting properties. It establishes the inert bromide ion bank. The bank is then activated by the addition of monopotassium persulfate, an oxidizer, which continually shocks. The reaction produces hypobromous acid.

HYPOBROMOUS ACID (HOBr) is the primary chemical species responsible for disinfection in bromine treated pools and spas. Like chlorine, bromine does combine with ammonia/nitrogen compounds to form bromamines. Unlike chloramines, bromamines have some very different properties. First, bromamines are effective sanitizers, so there is no need to differentiate between free and combined bromine. DPD #1 and DPD #2 drops OR a DPD #1 tablet is all that is needed to test the bromine (TAB - Total Available Bromine). Secondly, bromine is not as pH or temperature-dependent as hypochlorous acid. Like chlorine, bromine is sensitive to UV light. To date, there is not a stabilizer that is effective for bromine in outdoor applications. There is a great deal of conflict among aquatic professionals as to whether bromine causes eye and skin irritation. There is an odor that develops when bromamines are formed; it is just a different odor than that caused by chloramines. Because bromine is not as pH or temperature-dependent as chlorine, it is the better choice for a spa.

Most local Health Departments' regulation for TAB (total available bromine) in pools is 3.0 to 8.0 ppm, and it must be tested every two hours in main pool. The TAB for spas is 4.0 to 8.0 ppm, and it must be tested every hour in a spa.

SUPPLEMENTAL AND/OR MISCELLANEOUS SANITIZERS

The following miscellaneous sanitizers are acceptable forms of disinfection in some jurisdictions. Check with the local Health Department regulations for prior approval BEFORE considering one of these sanitizers. Some of them may be required to be used in combination with chlorine or bromine.

1. Ozone: A bluish, irritating gas with a pungent odor. It kills bacteria and oxidizes organic compounds, including chloramines, soaps, oils, and wastes. Ozone oxidizes rapidly and completely. Ozone continually shocks the water. This sanitizer uses a generator to produce ozone onsite. It is effective but very dangerous to humans and is usually a supplemental disinfection system used in conjunction with chlorine or bromine.
2. Electrolysis or Chlorine Generator: This method takes salt (chloride or bromide) being added to the pool, and an electric current is passed between a negative and a positive conductor, separates the element of salt solution and generates the HOCl or HOBr.
3. Ionization: Utilizes a current between silver and copper electrodes and releases these ions into the water. Copper kills algae, and silver destroys bacteria. Mineral staining is of concern with this product.
4. Iodine: The reduced pH dependence, increased pathogenic organism effectiveness, and residual persistence give Iodine superior advantages over conventional chlorination or Bromination of swimming pools.
5. Ultraviolet Light: A non-chemical disinfectant, water passes through the light to sanitize it. UV cannot be the singular disinfection system and will need to be used in conjunction with chlorine. The UV system is a secondary system added because it constantly eliminates the combined chlorine in the water. The UV rays will eliminate some FAC, so more chlorine will be used with this system in place.
6. Baquacil: This is a hydrogen peroxide-based product line. This is one product that must NOT be used with chlorine or bromine. Only products that are part of the baquacil line can be used. A warning sticker, stating that baquacil is used should be placed on the filter.

Fill in the chart with the range of each reading and the chemical name that raises and lowers each reading:

Chemical	Minimum	Maximum	Raise	Lower
Chlorine				
pH				
Total Alkalinity				
Calcium Hardness				
Cyanuric Acid				
Total Dissolved Solids	No Minimum		Not Applicable	

CHAPTER FIVE

Troubleshooting

Pool and Spa Water Treatment Problems

Chapter Objectives

1. Identify possible reasons why pool water may turn cloudy.
2. Identify some ways in which to clear up cloudy water.
3. To develop an understanding of possible damage that high mineral content can cause to a pool and how to prevent this from happening.
4. To be able to identify different types of algae, how to prevent algae, and how to treat algae.

References:
Reference 1: Hydrotech Chemical Corporation, "The Proper Management of Pool and Spa Water" by Kirk Mitchell.

COMMON WATER TREATMENT PROBLEMS

Water treatment problems will inevitably occur. The PSPO's job is to prevent as many problems as possible and to intervene quickly when problems do arise. It is very easy for a pool's chemistry to get out of balance and not always so easy to fix it. Many different factors can affect how a pool is treated. It is the operator's job to evaluate the pool's needs and assess the best possible treatment options. Every situation is different. One must take into consideration all the contributing factors before developing a treatment plan.

One thing is for certain, though; do not guess at what the problem might be. Do not randomly add chemicals just to see if something will work and do not add too many things all at once. Allow time for chemicals to circulate and take effect before adding more or another chemical. If you are unsure as to what the problem is or how to take care of it, consult a pool professional.

It is very important that the chemical logbook is well-kept. Most facilities have multiple operators on staff, and it is imperative that these operators communicate with each other daily. Always note in the logbook any chemical additions, with type and amount and any problem that may begin to develop, even if it seems minor. Sometimes the subtlest change during a shift can be an indication of a more serious problem. Catching it early can eliminate pool closure.

CLOUDY WATER

Water clarity is vital for the safety and enjoyment of the patrons. If a lifeguard is not able to see the bottom of the pool, then it is possible that they will not be able to see a swimmer in need of help. The water clarity is deemed acceptable if standing next to where the lifeguard would observe the deepest part of the pool; the operator can see the main drain (or a small black disc on the bottom of the pool). This safety concern is why swimming pools are closed during a rainstorm when the bottom is longer visible to the staff.

Cloudy water is one of the most common water treatment problems. Evaluate the situation carefully before deciding on a course of action. Below are a few questions to consider before choosing a treatment plan.

1. Is the water chemically balanced?
    a. Where is the disinfectant level? Has it dropped out of the proper range in the past few hours/days? What is the combined chlorine level? When was the pool shocked last?

b. Is the water within the parameters of the Saturation Index?
c. Have there been any improper chemical additions in the past few hours/days? Check the operator logbook.

2 Was there an extremely high bather load recently?
3 If the pool disinfection and chemistry seem in the proper ranges and nothing can be detected as far as chemical additions or anything else, next check the pump room.
4. Does the system need to be backwashed?
5. What is the flow rate? What is/are the filter pressure readings? Does the pump appear and sound like it is working correctly?

Circumstances can vary significantly from facility to facility. ATCS recommends trying the following things to help clear a cloudy pool:

- Shock the pool with an appropriate chemical (see chapter 4 for methods of shocking)
- Add a clarifying agent to the pool. A variety of different companies manufactures clarifying agents. Read the directions carefully. Some go directly into the water, while others are meant to be put into the skimmer. Some tell the user to turn the filtration system off for the night to allow the particles to settle. Consult a pool professional if you have any questions.
- If the pool needs to be backwashed, be sure to do that immediately. If the flow rate and pressure readings are in OK ranges, do not backwash. Sometimes a little dirt in the filter can help it filter better.
- Sand filters can also be flocked. This can be a tricky procedure and must be done using extreme caution. A filter aid is put into the sand filter, which makes the 60 microns of the distance between sand particles much smaller, allowing the filter to pick up more particles. However, this procedure can cause filter pressures to rise quickly. Be sure an operator with knowledge is present or directing this procedure if it is chosen. Diatomaceous earth can also be used in this manner, although it does not pick up quite as well.

PROLONGED CLOUDINESS:

1. Is the facility indoor or outdoor? Indoor facilities tend to be cloudier more often.
2. Filtration System:
   - Is the system properly sized?
   - What is the condition of the media? Has it been cleaned recently? Is the proper amount of sand in the tank? When was it replaced last? Is a flocculent indicated?
   - Does the water have a green tint to it?
     1) Algae: cloudy green water
     2) Dissolved copper: clear green water

MINERAL STAINING

Always check the fill water for calcium, iron, copper, manganese, etc. Use a chelating or **sequestering agent** to increase the water's ability to hold metals in solution, instead of allowing them to precipitate out and stain the pool's surface. Sequestering agents will not remove the stain. It will only prevent further staining suspending the mineral metal in the water and holding it color free. To help determine if water has a high mineral content:

a. Have a sample tested by a reputable laboratory
b. Fill a beaker with water and put ½ to ¾" of calcium hypochlorite into the beaker. The color change can indicate the following:

Green	=	Copper
Brown	=	Iron
Black	=	Cobalt
Pink	=	Manganese

ALGAE

The algae are the simplest members of the plant kingdom. They are microscopic, single-celled forms of plant life that exist in virtually all surface water and most groundwater. Their widespread presence and unrestricted transmission modes create a strong tendency for contamination of swimming pools and spas. Even the best-maintained swimming pools could experience algae problems. (Reference 1, pg. 43)
Hot weather, sunlight, heavy bather loads, and insufficient disinfectant level stimulate algae growth. Dissolved minerals can serve as chemical building blocks to further stimulate algae growth. Scale formations and surface deposits can facilitate algae growth by creating an ideal surface for algae attachment. Algae can enter the pool through dirt, leaves, bathing suits, wind, etc. (Reference 1, pg. 43)

Algae are found in many natural water supplies used for swimming (i.e., lakes, rivers, and oceans). Alone, algae are not harmful to the bather. (Reference 1) However, other problems can develop that put the patron at risk of injury or illness. It is the pool operator's responsibility to keep the water, decks, bathrooms, etc. clean and free of algae.

There are thousands of strains of algae found in water supplies. Three types more often occur in the swimming pool environment: Mustard (yellow), green, and blue-green (black).

1. Green algae are usually free-floating. (Reference 1, pg. 44) When it attaches to the walls, it is easily brushed away, leaving the operator to believe the problem has been solved. Simply brushing it is not the solution. Without proper treatment, certain strains of green algae can cause an "algae bloom." This means the pool can look like split-pea soup in a matter of hours. Keeping the disinfectant level in the proper range is the best means of prevention. Regular brushing of the walls is also essential in algae prevention.
2. Mustard (yellow) algae are often found on the shaded side of the pool. (Reference 1, pg. 45) It is a wall clinging alga that is very difficult to kill. A member of the green algae family, yellow algae, exhibits specific characteristics that make it very difficult to kill.
3. Blue-green (black algae) are slick round spots, usually congregating in areas of poor circulation. Black algae have a covering that makes it extremely difficult to kill. This outer covering must be removed prior to treating the algae. It is removed by using a brush with stainless steel bristles, brushing back and forth many times to remove the entire cover.

Note: Do not use a stainless-steel brush on any pool surface, except plaster without first checking with the builder.

Direct contact is the best to treat the slick spots once the outer covering is removed. Using small trichlor tabs, turn the system off at closing and place a tab on each black algae spot. Remove the following day before opening. Continued treatment is needed AFTER the spot disappears, to be sure all of it has been killed.

PREVENTION AND TREATMENT OF ALGAE

PREVENTION is the key when dealing with algae. Chlorine, Bromine, and Iodine offer excellent properties in the prevention and/or treatment of algae.

Bromine contributes to algicidal effects.
Algicidal: "Killing properties
Algistat: "Preventative" properties (Reference 1, pg. 45)

Quaternary Ammonium Compounds "Quats" are usually associated with "foaming algaecides." For maximum effectiveness, algaecidal concentrations of quats must be continuously present. Studies have indicated that quaternary ammonium compounds are vulnerable to "filter entrapment." If this is true, and weekly treatment amounts are not properly added, effective results with quaternary ammonium compounds will be unsuccessful. Do not use in spas or hot tubs.

Polyquat is non-foaming. If used according to label instructions, polyquat can reduce the consumption rate of maintenance halogen disinfectants. Polyquat is compatible with other pool treatment chemicals and exhibits very low toxicity to warm-blooded animals, a key feature of polyquat. When used as directed, polyquat is very effective in controlling black algae. The secret is to maintain recommended active concentrations as a preventative measure. In addition to its algaecidal/algaestatic properties, polyquat helps flocculate and remove organic matter, further reducing halogen demand. (Reference 1, pg. 45) There are also copper-based algaecides. While very effective on some types of algae, they do not always take care of the problem. There is also an increased risk of mineral staining due to high copper levels. Prevention is key when dealing with algae. Well-maintained pools should have minimal opportunity for algae spores to grow.

Recommendations for **PREVENTION of ALGAE**:

- Brush the pool walls regularly. (daily if the pool has developed algae in the past)
- Always keep the disinfectant levels in the proper ranges.
- Keep skimmer baskets clean and scrub the insides of the skimmers daily in pools that have developed algae in the past. Scrub the insides of the skimmers regularly no matter what. Under the weirs and in the skimmer throat is a haven for algae growth.
- Use algistats if the pool has a history of algae growth, especially during a very hot summer when the water temperature can become very warm.
- Keep the Cyanuric Acid (CYA) level below 70 ppm.
- Keep the filter(s) clean. Backwash as needed, but too often.
- Immediately treat the first sign of algae.

Recommendations for **TREATING VISIBLE ALGAE**:

- Sunlight is needed for algae to grow. Treat it during the day when the sun is shining.
- BRUSH, BRUSH, and BRUSH more!!! Use a stainless-steel algae brush (unless the pool surface is a vinyl liner or another surface where the manufacturer does NOT recommend using it. A nylon brush will work, just not as well.
- Methods of "Killing it":

  a. Superchlorinate the pool to 30 ppm. This is going to cause downtime but is one of the more effective methods. Be sure adding this amount of chlorine will not damage the pool surface, and remember to add a sequestering agent before, if high mineral content is a problem.

  b. Use some type of quat, polyquat, or copper-based algaecidal treatment. Follow the manufacturer's recommendations explicitly. Adding less than the required amount will not take care of part of the problem. The entire amount is needed for the treatment to be effective. This type of treatment can be extremely expensive.

  c. Black algae can be spot treated using tabs of trichlor or a specially made algae treatment for spot treatment. This usually involves turning off the system at night and placing the tabs directly on the black algae spots, then removing them before opening. Continue treating the spots for several days after visible signs of algae have disappeared.
- If it is possible, use a separate vacuuming system to avoid having the algae run through the filtration system. Even though it has been treated, it only takes a live spore to attach within the system and begin to grow again.
- After cleaning up the algae, be sure to thoroughly clean all equipment that was used in the process. Disinfect all brushes, vacuum heads, poles, etc.

Many other problems can and probably will develop in a pool/spa. Remember not to guess at the problem. If it is puzzling, consult a pool professional for advice. Avoid adding too many chemicals in a short period of time and give the chemicals time to circulate and take effect before adding more or something else.

Mistakes can be costly. It is the operator's responsibility to keep the water safe and inviting for the patrons. The PSPO is responsible for every person who gets in the pool. Always keep in close contact with Health Department regulation changes, attend seminars and workshops to keep up on the latest developments in the industry, and above all, always keep the water within the operating parameters in order to ensure a safe and fun environment for everyone.

Fill in the chart with the range of each reading and the chemical name that raises and lowers each reading:

Chemical	Minimum	Maximum	Raise	Lower
Chlorine				
pH				
Total Alkalinity				
Calcium Hardness				
Cyanuric Acid				
Total Dissolved Solids	No Minimum		Not Applicable	

Water Testing

The Swimming Pool Test Kit

CHAPTER SIX

Chapter Objectives

1. Identify good practices to follow when water testing.
2. Learn the common reagents used to test for chlorine and pH
3. Understand how the Taylor Test Kit work
4. Physically perform and record the above tests by participating in a testing lab.

WATER TESTING

Testing water is an easy thing to do. However, it is also very easy to make a mistake. Inexperienced pool/spa operators often take testing too lightly because it seems so easy to do. If a reading seems odd, do not automatically start adding chemicals to the pool. Always retake a reading that seems to be abnormal, and if there is a question as to the validity of reading, have someone else take the reading and/or take the reading with another test kit or different reagents. Reagents are the liquids, tablets, or powder used for the various tests needed to keep the water healthy.

All staff who are responsible for taking and recording readings need to be thoroughly trained in the proper procedures. Be aware of the local Health Department regulations and what to do if a reading does not fall into the acceptable range.

There are a variety of different test kits on the market. Check with the local Health Department to see which kit the Inspectors will use. It may be helpful to use a similar one. Most jurisdictions have Health Department guidelines regarding the appropriate test kit. Be sure to check the local health department regulation before purchasing a kit.

There are many methods for testing swimming pool water

1. Colorimetric: This relies on the operator matching the color of the sample to the color chart provided by the testing kit. It is important to have a consistent light source or white background to ensure consistency in the readings. Most seasonal operators will use this method for Chlorine and pH.
2. Titrimetric: In this method, the operator adds a certain amount of reagent and then adds titrant one drop at a time while mixing the water sample throughout until a color change results. The number of drops is then used to calculate the reading. Most operators use this method for Total Alkalinity and Calcium Hardness.
3. Turbidimetric: The operator adds a reagent to the water sample and mixes the solution. The solution is then used to fill the comparator tube until the dot at the base of the tube is no longer visible. Most operators use this for Cyanuric Acid.
4. Electronic Testing: The facility provides an automated system that will continuously provide readings. These testing systems will need to be calibrated to match the manual readings. Handheld systems are also available.

Water Testing Do’s

1. Read the test kit directions thoroughly.
2. Take the water sample well below the surface of the water.
3. Rinse the comparator/cells before beginning the test. Put the comparator into the water upside down and then turn right side up **at least 12 inches below the water’s surface, preferably 18 inches**. The Comparator is the device that the water readings are tested in. There are many different types of comparators; some test kits use individual testing cells. Refer to individual test kit directions.
4. Check with the local Health Department as to the frequency of testing and the proper ranges.
5. Keep all test kits and reagents out of sunlight and out of the reach of children.
6. Replace reagents according to manufacturer recommendations. Usually, liquid reagents should be replaced annually, and tablets at least every three years.
7. Compare all tests using the same light source or white background.
8. Alternate testing sites to assure all “dead spots” are adequately treated. (Dead spots are areas of poor circulation). Test between inlets and in at least three of water depth if possible.
9. Neutralize extremely high chlorine/bromine levels (above 10 ppm) before testing the pH. Use a drop of sodium thiosulfate (found in the test kit), before using the phenol red.
10. Always double-check a chlorine/bromine reading if it appears to be “0.” It can “bleach out.” **Bleaching out can happen if a chlorine or bromine reading is extremely high (above 10 ppm).**

Water Testing Don'ts

1. Do not put a finger or hand over the top of the comparator to shake the sample. Use the lid.
2. Do not interchange reagents with other kits.
3. Do not touch the inside of the comparator, the water to be tested, the tips of the reagent bottles, or the tablets.
4. Do not let the water sample remain in the comparator tube. Empty the tube immediately. Water samples that can sit in the tube will discolor the tube.
5. Do not dump the tested water sample into the pool.

SPECIFIC TESTING PROCEDURES

1. Disinfectant Determination

   a) **DPD** (N,N-Dimethyl-P-Phenylone-Diamine) is the most common chlorine/bromine testing reagent and can come in liquid or tablet form. This indicator turns the sample pink in the presence of a disinfectant residual. The pinker the sample, the higher the chlorine/bromine reading. Remember, an extremely high residual can cause the sample to “bleach out.” Instead of turning completely pink, the sample will go pink for a split second and then go clear.

      1) Tablets:
         - DPD #1: Tests free available chlorine and total available bromine
         - DPD #3: Tests total available chlorine (There is no #2 tablet)

      2) Liquid:
         - DPD #1 and #2: Tests free available chlorine and total available bromine
         - DPD #3: Tests total available chlorine

3) Powder

- Fill Comparator Tube to 25 ml
- Add two level scoops to sample
- Count drops of titrating reagent until sample turns from pink to clear

b) OTO (Orthotolidine), test measures total available chlorine only. A specified amount of OTO is added to a known volume of water, and the resulting yellow solution is compared to a standard OTO color comparator. Check with the local Health Department regarding the use of OTO test kits and how frequently the disinfectant needs to be tested. Usually, disinfectants are required to be tested every 1-2 hours.

2. pH

Phenol red is the most common pH-testing reagent. It is an acid/base indicator that changes color between pH 6.4 and 8.0 and can come in liquid or tablet, The more yellow the color, the lower the pH. The redder the color, the higher the pH. If the disinfectant level is HIGH (above 10 ppm), add 1 drop of liquid sodium thiosulfate (disinfectant neutralizer) to neutralize the sample before adding the phenol red. The pH usually needs to be tested every 1-2 hours, check with the local Health Department.

3. Total Alkalinity and Calcium Hardness

Both factors are tested through a procedure using a titrating reagent. Read the manufacturer's directions explicitly for these tests. Alkalinity and Calcium Hardness usually are required to be tested weekly. Check with your local Health Department.

4. Minerals

Copper, iron, and manganese are commonly found in pool water. Test kits are available for each of these minerals but usually are not required to be tested by most health departments.

5. CYA – Cyanuric Acid

For outdoor pools that use CYA as a stabilizer, this test must be used on a regular basis to ensure the level stays within the Health Department regulations. A weekly test is usually required. Check with the local Health Department.

6. TDS – Total Dissolved Solids

The TDS level must be tested periodically. Indoor pools with a high bather load should be checked according to local Health Department requirements. There are both test kits and electronic meters available.

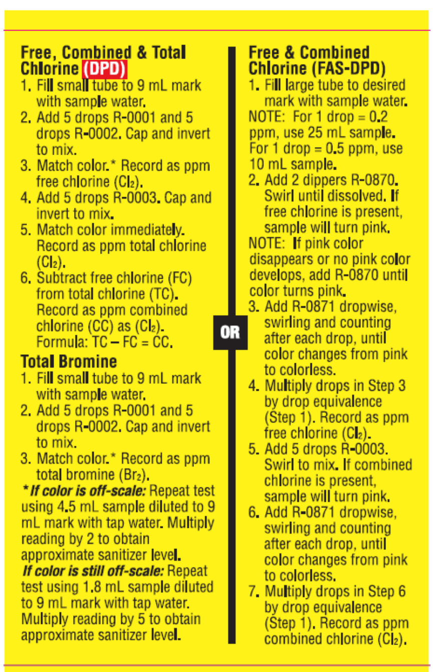
7. Acid/Base Demand

Some manufacturers offer reagents to add to the pH test to help determine the amount of acid or soda ash needed to bring the pool into proper balance. If the pH is high and needs to be lowered, use the acid demand. If the pH is low and needs to be raised, use the base demand. Once the number of drops has been added to achieve the correct color, use the supplied charts to determine the amount of chemical needed.

TAYLOR TEST KIT

An accurate and convenient way of testing pool water is to use the Taylor Complete Test Kit K-2005. This pool testing tool gives reliable and fast results. Inclusive upon the purchase of this testing tool are Booklet, Ink, Circular Watergram, case (top/bottom/handle), & Reagents (DPD#1, DPD#2, DPD#3, PH IND Sol, Acid & Base Demand, Thiosulfate N/10, TOT ALK IND, SULFURIC ACID, CALCIUM BUFF, CALCIUM IND LIQ, HARDNESS, CYA). Use this product properly by following the steps below and those provided with the kit:

- Read the labels and all the instructions in the kit.
- Make sure to store away from the reach of children and in a cool, dark area.
- The reagents should be replaced at least once a year.
- Solutions should not be disposed in anywhere. After each test, the tubes must be cleaned.
- Water samples should be obtained 18” or 45 cm below the pool water surface.



Free, Combined & Total Chlorine (DPD)
1. Fill small tube to 9 mL mark with sample water.
2. Add 5 drops R-0001 and 5 drops R-0002. Cap and invert to mix.
3. Match color.* Record as ppm free chlorine (Cl_2).
4. Add 5 drops R-0003. Cap and invert to mix.
5. Match color immediately. Record as ppm total chlorine (Cl_2).
6. Subtract free chlorine (FC) from total chlorine (TC). Record as ppm combined chlorine (CC) as (Cl_2). Formula: TC – FC = CC.

Total Bromine
1. Fill small tube to 9 mL mark with sample water.
2. Add 5 drops R-0001 and 5 drops R-0002. Cap and invert to mix.
3. Match color.* Record as ppm total bromine (Br_2).

If color is off-scale: Repeat test using 4.5 mL sample diluted to 9 mL mark with tap water. Multiply reading by 2 to obtain approximate sanitizer level.
If color is still off-scale: Repeat test using 1.8 mL sample diluted to 9 mL mark with tap water. Multiply reading by 5 to obtain approximate sanitizer level.

OR

Free & Combined Chlorine (FAS-DPD)
1. Fill large tube to desired mark with sample water.

NOTE: For 1 drop = 0.2 ppm, use 25 mL sample. For 1 drop = 0.5 ppm, use 10 mL sample.

2. Add 2 dippers R-0870. Swirl until dissolved. If free chlorine is present, sample will turn pink.

NOTE: If pink color disappears or no pink color develops, add R-0870 until color turns pink.

3. Add R-0871 dropwise, swirling and counting after each drop, until color changes from pink to colorless.
4. Multiply drops in Step 3 by drop equivalence (Step 1). Record as ppm free chlorine (Cl_2).
5. Add 5 drops R-0003. Swirl to mix. If combined chlorine is present, sample will turn pink.
6. Add R-0871 dropwise, swirling and counting after each drop, until color changes from pink to colorless.
7. Multiply drops in Step 6 by drop equivalence (Step 1). Record as ppm combined chlorine (Cl_2).

FOR CHLORINE TEST (Free, Combined, or Total):

- Wash and fill the small comparator tube with to 9 ml water sample
- Add 5 drops of DPD RGT #1 and 5 drops of DPD RGT #2. Close the cap and swirl to mix.
- Match the resulted color with the colors in the chart. Record this one as parts per million free chlorine (ppmFC).
- Add 5 drops of DPD RGT#3. Recap and swirl to mix.
- Match the resulted color again and record as parts per million chlorine (ppmTC)
- Deduct ppmFC from ppmTC and record the result as parts per million Combined Chlorine. The formula: TC—FC = CC.

TOTAL BROMINE TEST

- Wash and fill the small comparator tube with 9 ml water sample.
- Add 5 drops of DPD RGT#1 and 5 drops of DPD RGT#2. Close the cap and swirl to mix.
- Match the resulted color with the colors in the chart and record it as parts per million Total Bromine.
- Take note: if the resulted color is off the scale, then repeat the test by using 4.5 ml water sample diluted with 4.5 ml tap water. The reading should be multiplied by two to obtain a more precise sanitizer level. If the resulted color is still off-scale, then repeat the test again by using 1.8 ml water sample diluted with 7.2ml tap water. The reading should be multiplied by 5 to obtain a more precise sanitizer level.

pH
1. Fill large tube to 44 mL mark with sample water.
2. Add 5 drops R-0004. Cap and invert to mix.
3. Match color. Record as pH units. If color is between two values, pH is average of the two. To LOWER pH: See Acid Demand. To RAISE pH: See Base Demand.

Acid Demand
1. Use treated sample from pH test.
2. Add R-0005 dropwise. After each drop, count, cap and invert to mix, and compare color until desired pH is matched. See Treatment Tables in Guidebook (#2004B) to continue.

Base Demand
1. Use treated sample from pH test.
2. Add R-0006 dropwise. After each drop, count, cap and invert to mix, and compare color until desired pH is matched. See Treatment Tables in Guidebook (#2004B) to continue.

pH TEST

- Wash and fill the large comparator tube with 44 ml water sample.
- Add 5 drops of PH IND SOL. Close the cap and swirl to mix.
- Match the resulted color with the colors in the chart and record it as pH units. If the result suggests a pH adjustment, save the sample for future reference.
- For a sample color that falls between two values, the average of these two values is the pH unit.

ACID DEMAND TEST

- Obtain the used sample from pH Test.
- Add ACID DEMAND REAGENT. Count each drop, then mix and compare the color to the color standards in the chart until the desired pH level is obtained. Check the treatment table to continue.

BASE DEMAND TEST

- Obtain the used sample from pH Test.
- Add BASE DEMAND REAGENT. You need to count each drop, then mix and compare the color to the color standards in the chart until the desired pH level is obtained. Check the treatment table to continue.

TOTAL ALKALINITY TEST

- Wash and fill the large comparator tube with 25 ml water sample.
- Add 2 drops of THIOSULFATE N/10. Close the cap and mix.
- Add 5 drops of TOTAL ALK IND. Close the cap and mix. The sample should turn green.
- Add SULFURIC ACID. Count and mix after each drop until the water sample's color changes from green to red.
- Multiply the drops of SULFURIC ACID by ten (10). Record the result as parts per million Total Alkalinity as Calcium Carbonate.
- When Total Alkalinity is high, use this testing method: obtain a 10 ml water sample, add 1 drop of THIOSULFATE N/10, 3 drops of TOTAL ALK IND, and multiply the drops of SULFURIC ACID by 25.

Total Alkalinity (TA) Test
1. Rinse and fill large comparator tube to 25 mL mark with water to be tested.*
2. Add 2 drops R-0007. Swirl to mix.
3. Add 5 drops R-0008. Swirl to mix. Sample will turn green.
4. Add R-0009 dropwise, swirling and counting after each drop, until color changes from green to red.
5. Multiply drops in Step 4 by 10. Record as parts per million (ppm) total alkalinity as calcium carbonate ($CaCO_3$).

CALCIUM HARDNESS TEST

- Rinse and fill large comparator tube to 25 mL mark with water to be tested.
- Add 20 drops R-0010. Swirl to mix.
- Add 5 drops R-0011L. Swirl to mix. If calcium hardness is present, the sample will turn red.
- Add R-0012 dropwise. After each drop, count and swirl to mix until color changes from red to blue.
- Multiply drops in Step 4 by 10. Record as parts per million (ppm) calcium hardness as calcium carbonate.

*When high CH is anticipated, this procedure may be used: Use 10 mL sample, 10 drops R-0010, 3 drops R-0011L, and multiply drops in Step 4 by 25.

Calcium Hardness (CH) Test
1. Rinse and fill large comparator tube to 25 mL mark with water to be tested.*
2. Add 20 drops R-0010 (or use pipet provided and fill to 1 mL mark). Swirl to mix.
3. Add 5 drops R-0011L. Swirl to mix. If calcium hardness is present, sample will turn red.
4. Add R-0012 dropwise, swirling and counting after each drop, until color changes from red to blue.
5. Multiply drops in Step 4 by 10. Record as parts per million (ppm) calcium hardness as calcium carbonate ($CaCO_3$).

CYANURIC ACID TEST

- Wash and fill the CYA dispensing bottle with 7 ml water sample.
- Add 7 ml CYANURIC REAGENT. Close the cap and swirl to mix for 30 seconds.
- Add the cloudy solution gradually into the small comparator tube until the black dot on the base is no longer visible when viewed from the top.
- Read the level of the liquid on the back of comparator block and then record it as parts per million (ppm)

Cyanuric Acid (CYA)

1. Fill bottle (#9191) to 7 mL mark with sample water.
2. Add R-0013 to 14 mL mark. Cap and mix for 30 seconds.
3. Transfer cloudy solution to small tube until black dot on bottom just disappears when viewed from top.
4. Read tube at liquid level on back of comparator block. Record reading as ppm cyanuric acid (CYA).

Below is a sample of the Taylor Test Kit Lid. It includes how to use DPD powder to test Free Available Chlorine.

Guidebook (#2004B) amplifies these instructions and should be read to use this product properly.

POOL & SPA WATER TESTS

1. Keep test kit out of reach of children.
2. Read precautions on all labels.
3. Store test kit in cool, dark place.
4. Replace reagents once each year.
5. Do not dispose of solutions in pool or spa.
6. Rinse tubes before and after each test.
7. Obtain samples 18" (45 cm) below water surface.
8. Hold dropper bottle vertically when dispensing reagent.

Instr. #5140

Free & Combined Chlorine Test

1. Rinse and fill large comparator tube to desired mark with water to be tested.

NOTE: For 1 drop = 0.2 ppm, use 25 mL sample. For 1 drop = 0.5 ppm, use 10 mL sample.

2. Add 2 dippers R-0870. Swirl until dissolved. If free chlorine is present, sample will turn pink.

NOTE: If pink color disappears, add R-0870 until color turns pink.

3. Add R-0871 dropwise, swirling and counting after each drop, until color changes from pink to colorless.
4. Multiply drops in Step 3 by drop equivalence (Step 1). Record as parts per million (ppm) free chlorine (Cl_2).
5. Add 5 drops R-0003. Swirl to mix. If combined chlorine is present, sample will turn pink.
6. Add R-0871 dropwise, swirling and counting after each drop, until color changes from pink to colorless.
7. Multiply drops in Step 6 by drop equivalence (Step 1). Record as ppm combined chlorine (Cl_2).

pH Test

1. Rinse and fill large comparator tube to 44 mL mark with water to be tested.
2. Add 5 drops R-0004. Cap and invert to mix.
3. Match color with color standard. Record as pH units and save sample if pH needs adjustment. If sample color is between two values, pH is average of the two. To LOWER pH: See Acid Demand Test. To RAISE pH: See Base Demand Test.

Acid Demand Test

1. Use treated sample from pH test.
2. Add R-0005 dropwise. After each drop, count, cap and invert to mix, and compare with color standards until desired pH is matched. See Treatment Tables to continue.

Base Demand Test

1. Use treated sample from pH test.
2. Add R-0006 dropwise. After each drop, count, cap and invert to mix, and compare with color standards until desired pH is matched. See Treatment Tables to continue.

Total Alkalinity (TA) Test

1. Rinse and fill large comparator tube to 25 mL mark with water to be tested.*
2. Add 2 drops R-0007. Swirl to mix.
3. Add 5 drops R-0008. Swirl to mix. Sample will turn green.
4. Add R-0009 dropwise, swirling and counting after each drop, until color changes from green to red.
5. Multiply drops in Step 4 by 10. Record as parts per million (ppm) total alkalinity as calcium carbonate ($CaCO_3$).

****When high TA is anticipated**: Use 10 mL sample, 1 drop R-0007, 3 drops R-0008, and multiply drops in Step 4 by 25.

Calcium Hardness (CH) Test

1. Rinse and fill large comparator tube to 25 mL mark with water to be tested.*
2. Add 20 drops R-0010 (or use pipet provided and fill to 1 mL mark). Swirl to mix.
3. Add 5 drops R-0011L. Swirl to mix. If calcium hardness is present, sample will turn red.
4. Add R-0012 dropwise, swirling and counting after each drop, until color changes from red to blue.
5. Multiply drops in Step 4 by 10. Record as parts per million (ppm) calcium hardness as calcium carbonate ($CaCO_3$).

****When high CH is anticipated**: Use 10 mL sample, 10 drops R-0010 (or use pipet provided and fill to 0.5 mL mark), 3 drops R-0011L, and multiply drops in Step 4 by 25.

Cyanuric Acid (CYA) Test

1. Rinse and fill bottle (#9191) to 7 mL mark with water to be tested.
2. Add R-0013 to 14 mL mark. Cap and mix for 30 seconds.
3. Slowly transfer cloudy solution to small comparator tube until black dot on bottom just disappears when viewed from top.
4. Read tube at liquid level on back of comparator block. Record reading as parts per million (ppm) cyanuric acid (CYA).

Sodium Chloride (Salt) Test

For 1 drop = 200 ppm

1. Rinse and fill small sample tube (#9198) to 10 mL mark with water to be tested.
2. Add 1 drop R-0630. Swirl to mix. Sample will turn yellow.
3. Add R-0718 dropwise, swirling and counting after each drop, until color changes from yellow to a milky salmon (brick red).

NOTE: A white precipitate will form as R-0718 Silver Nitrate Reagent is added to the sample. Do not add enough R-0718 Silver Nitrate Reagent to give a brown color. First change from yellow to a milky salmon (brick red) is the endpoint.

4. Multiply drops of R-0718 by 200. Record as parts per million (ppm) salt as sodium chloride (NaCl).

taylor 110317

Fill in the chart with the range of each reading and the chemical name that raises and lowers each reading:

Chemical	Minimum	Maximum	Raise	Lower
Chlorine				
pH				
Total Alkalinity				
Calcium Hardness				
Cyanuric Acid				
Total Dissolved Solids	No Minimum		Not Applicable	

CHAPTER SEVEN

Chemical Automation

Chapter Objectives

1. Understand how automated systems test for chlorine and pH
2. Understand how to properly maintain an automated chemical testing system

Chemical Automation

Chemical automation, as it is often employed in swimming pools and spas, utilizes modern technology to sense, display, and make necessary corrections to the two primary components of water quality – pH and disinfectant. Measuring pH and sanitizer levels are accomplished by placing pH and ORP (Oxidation Reduction Potential) electrodes in a representative sample of recirculating water. The electrodes or sensors produce a small millivolt signal which is passed to the chemical controller. The chemical controller, in turn, interprets and processes these signals for display and chemical control. Finally, the pH and ORP values are compared to a user-defined set point, and the controller actuates the proper chemical feed device in accordance to demand.

pH

pH is measured on a scale ranging from 0 to 14, with pH 7.0 considered neutral. The term pH is derived from the Latin words potens hydrogen meaning hydrogen power. By definition, pH is a measurement of the acidity or concentration of hydrogen ion H+ present in an aqueous solution. pH below 7.0 is considered acidic and above 7.0 base or alkaline. pH is a significant variable in determining water quality as it affects sanitizer activity, color, and human compatibility with the water. When measuring pH with a chemical automated testing system, the digital readout must be calibrated to match the manual test.

ORP

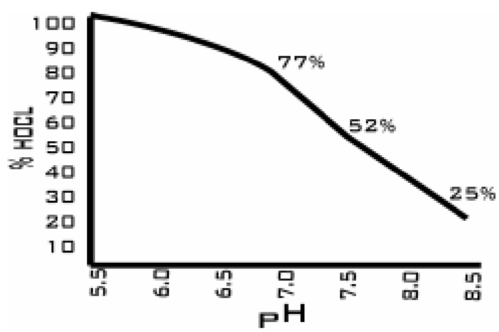
Oxidation-reduction potential, expressed in millivolts, is a measure of the oxidizing capability present in water. Unlike a free chlorine reading, ORP is not fooled by the effects of pH, TDS, stabilizers, or non-chlorine oxidizers. The typical DPD test kit can differentiate between free available chlorine and the less effective combined chlorine. However, free chlorine is composed of two distinct parts or species known as Hypochlorous acid (HOCl) and hypochlorite ion (OCl-). Like free and combined chlorine, HOCl and OCl- are not equal in their ability to sanitize. The ionic form of chlorine OCl- is slow-acting, while the Hypochlorous acid (HOCl) is 80 to 300 times more effective. It can be said that an ORP sensor measures the Hypochlorous acid primarily and therefore provides a more useful measure of water quality. The ORP reading on an automated testing system may vary from pool to pool when the number is compared to the manual test result. The important thing is to find the correct setpoint that matches the desired manual test kit, check to see what the corresponding ORP reading is on your machine at that moment, and set the machine to match that ORP reading from that point forward.

Water Balance/Quality

Water balance is comprised of several key variables – pH, calcium hardness, total alkalinity, temperature, and total dissolved solids. Water balance in swimming pools is usually calculated by the use of the Langelier saturation index. SI = pH + TF + log CH + Log ALK – Constant. Commercially available tables can ease the use of this index. When water is balanced, the index produces a zero value. Positive values above +0.3 lead to scaling and cloudy water, while negative values below –0.3 will cause corrosion of pool surfaces and equipment. It is important to note that each of these variables contributes to the water quality and have secondary effects on each other. The use of chemical automation equipment will significantly reduce the hourly and daily work involved in maintaining proper water balance but is not a substitute for manually testing and correcting the variables that are not under the system's control. The relationship between ORP and the sanitizer's ppm is highly correlated only when water balance is tightly controlled

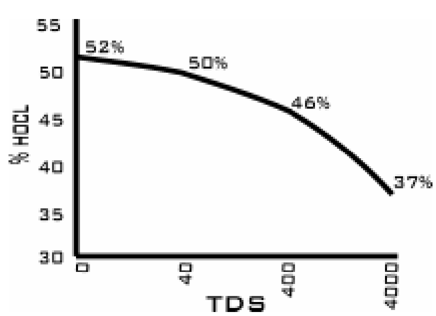
PH/ORP Relationship

As discussed above, free chlorine is comprised of two species: HOCl and OCl^-. The relative amount present in chlorinated systems will be determined by pH. At a pH of 7.5, free chlorine will be divided almost equally between these two species. However, as pH increases, more free chlorine takes the form of the less effective OCL- chlorine ion. Conversely, as pH falls, more free chlorine will dissociate into the more active Hypochlorous acid HOCl. In fact, at pH 8 only 20% of free chlorine is available in the fast-killing HOCl form. ORP measurements inherently compensate for the effect of pH. Table 1 illustrates this for the relevant pH range for swimming pools. It is important to note that this graph is based on a fixed temperature of 25ºC or approximately 77º F. Higher temperatures, typical for spas 104º F = 40ºC, shift the curve so that less free chlorine is available in the HOCl killing form at a given pH.



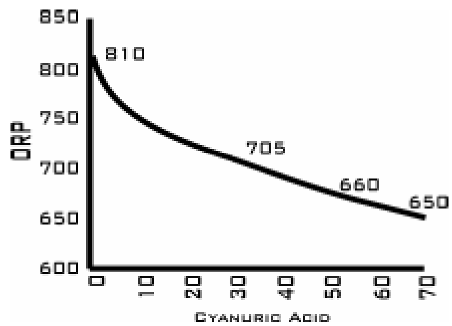
TDS/ORP Relationship

Like pH, total dissolved solids (TDS) affect the dissociation of free chlorine between HOCl and OCl^-. As TDS increase from 0 to 4,000 ppm, the amount of free chlorine available as HOCl decreases. The effect of TDS is less drastic than the pH shift but is of notable significance. At pH 7.5, 400 ppm TDS decreases HOCl to 46%, and at 4,000, only 37% free chlorine is available in fast-killing HOCl form. The graph below illustrates the shift typical for pools 0-4,000 ppm TDS. It is important to note that these values are stated for water at 25ºC, and the effects of higher pH or temperature are cumulative.



Cyanuric Acid Effect on ORP

Cyanuric acid stabilizers were first introduced to the swimming pool industry in the early 1950s, and controversy has followed since. The primary benefit of Cyanuric acid is to protect free chlorine from being destroyed by the UV rays of sunlight. A stabilized pool with 25-50 ppm Cyanuric acid will lose 10-15% free chlorine to UV rays in 2 to 3 hours, while an unstabilized pool will lose 90% over the same time. As shown below, the use of Cyanuric acid will decrease the ORP of 1 ppm free chlorine in a pool at pH 7.4 and 23^{o} C as Cyanuric acid levels below maximum recommended levels (generally 100 ppm) and hold it as constant as possible.



ORP Research and Validation in Swimming Pools

As early as 1936, Harvard University studied the relationship between ORP and bactericidal activity of chlorine on germs and bacteria and concluded that ORP readings were highly correlated to the bacteriological quality of the water. Further laboratory studies conducted by the German Federal Health Office in 1968 showed the rate of kill for E. Coli organisms in swimming pool water is dependent on ORP and not free chlorine residual. They further concluded the kill time for E. Coli is just a fraction of a second at redox (ORP) of 650 mV. In 1971, the World Health Organization (WHO) adopted an ORP standard of 700 mV for drinking water disinfection. Shortly thereafter, the DIN standard for swimming pools and spas was adopted by Germany, France, and most European countries. In the U.S., an exhaustive study of commercial spas was conducted by the Oregon State Health Department and the Yale University of Medicine, which found ORP the only significant predictor of bacterial quality. The significance of these findings cannot be overstated.

Automation Requirements

U.S. Health officials and industry have begun to make progress in adopting the standards so widely accepted by the rest of the world. Several State and County Health Departments have mandated the use of chemical automation equipment. The most notable requirements have been enacted at the State level for the automation of commercial spas, as summarized below:

State	Effective Date	Summary
Ohio	March 1, 1994	effective January 1, 1996 all spas shall provide an approved automatic chemical controller
Utah	September 16, 1996	Spa pools built after September 16, 1996 must be equipped with pH/ORP controller.
Florida	Draft	ORP controllers shall be provided on Spa pools to insure proper disinfection levels.
South Carolina	January 1, 1997	New and existing spas with a record of improper water chemistry shall be equipped with automatic controllers.

Reprinted with permission from Cullin Tate, Chemical Automation Technologies, Inc.

CHAPTER EIGHT

Water Circulation

Chapter Objectives

1. Explain why it is imperative that main drains NOT present a suction entrapment hazard.
2. Explain how to prime a pump.
3. Identify reasons why a pump can cavitate, and how to prevent this from happening.
4. To gain an understanding of how water circulates through the pump room.
5. To explain why skimmers and return fittings must be adjustable.
6. Identify the component parts of a circulation system and whether they are on the suction or pressure side of the pump.
7. To explain when a heater must be turned off.

WATER CIRCULATION

The growth of bacteria, algae, and other micro-organisms can make swimming in stagnant (non-moving) water a health hazard. The longer the water is still, the higher the health risk. Under most circumstances, standing water will remain reasonably safe for approximately 2 hours, possibly up to 2 days with no swimmers. The disinfectant levels play an essential role in how long the water will remain safe.

Pools should be designed to mix and circulate the water as much as possible. Each circulation system is comprised of influent and effluent lines. The influent lines are those that pull, suction, or vacuum the water out of the pool basin toward (into) the pump and filtration systems. The effluent lines are those that push or return the water back into the pool basin, away from the pump and filtration systems. All system components must be working in conjunction to effectively provide complete circulation of the water and avoid dead spots. Dead spots are areas of poor circulation, where there is little water movement. As a result, the disinfectant may not get to those areas, and bacteria and algae can grow undeterred. In outdoor pools, in addition to the many other possible causes of ineffective circulation, wind and weather conditions may also disrupt the water flow pattern and cause dead spots to occur.

The main drains, skimmers, and vacuum lines are all components of the influent side of the circulation system.

MAIN DRAIN

The main drain is always located in the deepest point of the pool, and there will be more than one drain cover. The main drain is a suction or vacuum line that pulls water from the bottom of the pool. Main drains need to be equipped with a hydrostatic relief valve. The hydrostatic relief valve is located at the lowest point in the pool basin and, when opened, will allow groundwater to escape into the pool basin to relieve the pressure beneath the pool structure. This valve prevents an empty pool from floating and sustaining significant damage. In some jurisdictions, the hydrostatic relief valve is a requirement of state or local pool regulations.

All main drains present the risk of suction entrapment. Suction entrapment is when a swimmer gets inextricably pulled into the suction or vacuum force of the main drain and cannot free themselves. Many deaths and injuries have been attributed to suction entrapment, and, as a result, Congress passed the Virginia Graeme Baker Act, which requires all commercial pools to have special anti-vortex drain covers and at least two main drains in order to prevent suction entrapment. An anti-vortex drain cover is larger and rounded instead of flush with the pool bottom. The water is pulled in and under the cover. When properly secured, an anti-vortex drain cover significantly reduces the potential for suction entrapment.

In addition, in many jurisdictions, it is a requirement that, as part of the daily opening checklist, all main drain covers are checked for security. Some Health Departments also require that a sign is clearly posted, identifying the switch that turns OFF the pump in the event of an emergency. This sign needs to clearly visible to ALL who walk into the pump room.

DAILY ENTRAPMENT PREVENTION

There are several types of entrapment, such as hair, limb, body, evisceration/disembowelment, and mechanical.

YOUR LOCAL HEALTH DEPARTMENT REGULATION ON MAIN DRAIN COVERS/PREVENTION OF SUCTION ENTRAPMENT INJURIES IS:

1. **Check Drain Covers Daily**
2. **Check Water Is Above Bottom of Skimmers**
3. **Empty Skimmer Baskets Daily**
4. **On/Off Switch is Clearly Marked**

SKIMMER/GUTTER

Skimmers/Gutters are located around the perimeter of the pool surface. Most swimming pools are designed so that the skimmer or gutter line pulls 60-80 % of the water flowing into the pump system. Most jurisdictions require that at least 50% of the total water entering the circulation system is pulled from this line and that baskets are cleared daily to ensure constant flow through the skimmer.

A gutter is a ledge that runs around the entire perimeter of the pool over which water flows constantly. The water is then drawn from the gutters into the pump system. A pool with a gutter system can be advantageous because it helps eliminate "dead spots" by drawing water from the entire water surface at all times. In order to attain effective circulation, the water should always be flowing over the edge slightly. Some gutter systems are equipped with agitators. If there are agitators, the water level should be ½ of the way up the gutter edge.

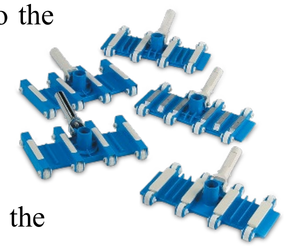
Skimmers are inlets located at certain intervals around the perimeter of the pool that draws the surface water into the pump system. Weirs are the doors or flaps on the skimmer openings which prevent major debris from clogging the skimmers, thus allowing the skimmers to effectively pull the surface water into the skimmer lines. **Weirs** are crucial for proper operation of the skimmer and effective circulation. They are either spring-loaded or hinged. In addition to weirs, skimmers also have a skimmer basket that catches the smaller debris that flows past the weir and some sort of adjustment flap that allows the operator to control the flow of water from the skimmer into the pump system. Many times, there is also a device in the bottom of the skimmer hole called a **turtle** that prevents large debris from clogging skimmer lines as well as giving the pool operator the ability to adjust the amount of suction in that skimmer. A basket and a securely fitting lid must be operational and unbroken on all skimmers.

VACUUM LINE

A pool may or may not have a designated vacuum line. If the pool has a vacuum line, the ports will be placed around the pool perimeter, usually below the skimmer level. These ports must be covered, and the valve in the pump room must be turned off when the line is not in use to prevent suction entrapment. The ports should be placed so that all areas of the pool can be reached with the vacuum hose.

When vacuuming a pool, remember to do the following:

- Attach the vacuum head to the pole, and the hose to the vacuum head.
- Place the vacuum head into the water and allow it to sink to the bottom.
- Prime the vacuum hose by filling it with water BEFORE hooking it up to the port. This is most easily achieved by feeding the hose straight down the wall into the water, so it fills with water.
- Plug the other end of the hose into the vacuum hole or bottom of the skimmer, whichever is used to vacuum.



DO NOT PLUG THE VACUUM HOSE INTO THE PORT, UNLESS IT HAS WATER IN IT!

These three suction lines (2 if there is no vacuum line) converge at some point to create a single influent line that flows into the circulation system. All water drawn from the pool basin will flow through this line into the Hair and Lint Pot.

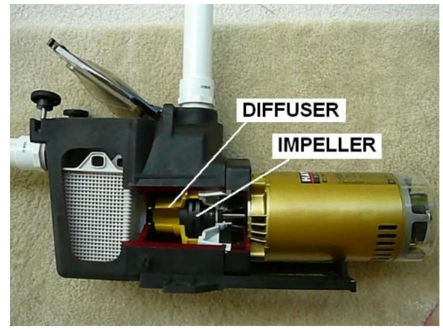
BALANCING CHAMBER

Balancing tanks or chambers are reservoirs that collect water from the influent lines prior to the pump. These are commonly found in swimming pools that utilize gutters.

HAIR AND LINT POT (HAIR STRAINER)

The hair and lint pot is a component of the pump system located before the pump to catch debris. It filters the incoming water, trapping large particles in a basket. The basket must be cleaned frequently to ensure the pump is protected and the water flow is not inhibited. While in most systems, the hair and lint pot is attached to the pump; this is not always the case. Either way, the hair and lint pot will always be in front of the pump. Once the water has passed through the hair strainer, it then moves through the pump by means of the pump's impeller. An impeller is a rotor located within the pump that draws the water through the system by turning. If the water flow becomes hampered and the pump begins to fill with air, the pump can cavitate. Pump cavitation is a violent shaking of the pump that happens when there is not a smooth flow of water through the pump. The impeller relies on water flow to sustain its rhythm. When a pump cavitates too long, the impeller will be damaged or destroyed, and eventually, the motor itself will be damaged or destroyed from the heat and vibration

PUMP



The pump is the device that causes the water to move through the circulation system. The pump acts much like the human heart. The heart causes blood to flow through the body. Similarly, the pump causes water to flow through the circulation system. Swimming pool pumps are centrifugal suction pumps. The name is derived from "centrifuge," meaning to go around and "suction," which indicates that the water is pulled to the pump. The pump is made up of three components: the impeller, the pump housing, and the motor. The seal is what keeps the "wet end" (impeller and housing) separate from the "dry end" (motor). When the motor spins the impeller (clockwise from the rear of the pump), it creates a vacuum that is filled by more water rushing to take the place of the water that was forced out. This vacuum is what moves the water through the pump.

"Priming the Pump" is essential. The system must always have water running through it. Before starting the motor, be sure water is in the hair and lint strainer and in the piping. Use buckets of water or a hose if needed. Once all spaces have been filled with water, re-secure the lid on the hair and lint pot and start the pump. Once the pump is running and has built up some pressure, slowly open the valves to begin flow.

Any air on the suction side of the pump will prohibit a pump from "catching prime." It is critical that all possible sources of a leak be eliminated. The lid on the hair and lint pot is a very common source of air. The lid must be securely in place, and the gasket or "O" ring must fit tightly.

Pool pumps are situated in one of three locations with respect to the water level of the pool. They are "at-level," "above-ground," or "below-ground." If a pump is at the level of the pool, the water in the pool will equalize with the water level at the top of the hair and lint strainer when you have the lid off and all the valves open. This means that the "header" (skimmer, main drain, etc.) valves do not need to be closed when cleaning the strainer. This system is usually self-priming. Above-ground pumps are the most difficult with which to work. The header valves must be closed prior to turning off the pump in order to clean the strainer. If these valves are not closed, all the water will run back to the pool, and the pump will need to be re-primed prior to starting the system. Below-level systems (flooded suction) are the easiest to work with. All header valves must be closed before cleaning the hair strainer to prevent the water from rushing from the pool and out of the hair strainer. These pumps are called "flooded suction" pumps and prime themselves with gravity.

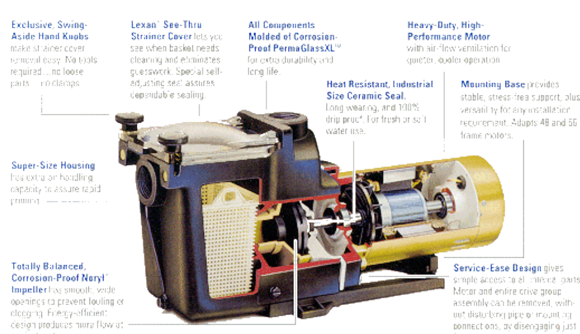
A pump curve is a graph showing the performance capabilities of a pump. It is measured in Feet of Head. Pumps that are too small will not produce the proper turnover rate. Pumps that are too large will force water through the filter so quickly that it will not filter properly.

Remember to have the pump shut-off switch clearly marked so that it is visible to anyone who may go into the pump room for the first time during an emergency.

Water comes into the pump from the suction (Vacuum) line. Once it passes around the impeller, it will be pushed the rest of the way through the system. This is the effluent side or pressure side of the system. The pressure side of the system is comprised of the motor, filters, the heater (if applicable), chemical feeders, return lines, and inlets. The pressure side of the system has the job of delivering the water back to the pool basin.

MOTOR:

The motor makes the pump work. The impeller is attached to the shaft of the motor, and the motor spins the impeller, circulating the water. The number of gallons per minute a pump will produce is dependent on the power of the motor.



TURNOVER RATE

Turnover rate is the amount of time it takes all of the water in the pool to go through the filtration system and return to the pool basin. Turnover rates and how to calculate the turnover rates are discussed more thoroughly in chapter 9. Most Health Departments have minimum requirements for turnover rates to ensure that the pool's water is sufficiently filtered and disinfected.

Most local health departments' regulations for maximum/minimum turnover rate are:

Swimming Pools	**6 Hours**
Wading Pools	**2 Hours**
Spas	**30 Minutes**

FILTERS

The water then moves from the pump into the filtration system. **Filters remove small particulate matter from the pool**. (Filtration will be discussed more thoroughly in Chapter 9.) Solid material, when in water, may dissolve or remain suspended. If the material does not dissolve, it is considered particulate matter. The water passes through the filter media (sand, DE, or cartridge), leaving behind any particulate matter that is trapped by the filter media.



HEATERS

If the pool has a Heater, it should be installed after the filter and before the chemical injection points. Most systems require the heater to be turned off when the circulation pump is turned off for any reason, even if it will be off for only a few minutes. Some heaters are to be turned off several minutes before turning off the rest of the system (see manufacturer's instructions). Only turn the heater back on after the main (re-circulating) pump has been turned back on.

In order to size the heater, the operator BTUSs = Gallons x 8.33 x °F temperature rise

CHEMICAL FEEDERS

Chemical Feeders introduce the disinfectant chemicals and pH adjusters to the filtered water. Most systems have the chemical injection points AFTER the filters and heaters, although some are designed to be injected prior.

RETURN LINE AND INLETS (RETURNS)

The return line carries cleaned, heated, and chemically treated water back to the pool. It enters the pool through inlets or returns. These inlets or returns are located on the sides or the bottom of the pool. On a gutter pool, the returns can be found around the bottom edge of the gutter. Inlets are adjustable to ensure that each one has the same amount of pressure, thus producing an equal distribution of disinfected water.

In order to accomplish this, the inlets (returns) and skimmers must be adjustable so those closest to the pump are closed more, and those farther away are open more. This assures adequate circulation to all areas of the pool. Uranine dye is a powder or liquid reagent used to check the circulation. It is put into a skimmer and will go through the system, coming out of the returns, showing equal distribution of flow for pool circulation. Many Health Departments use this dye to test the circulation at least once a year.

VALVES

There will be many valves and pipes in the pump room. Most commercial valves are open if the handle is running with the pipe and closed if the handle is running across the pipe.

Most jurisdictions require that all valves and pipes are colored and/or labeled for easy identification. A valve legend should be posted in the pump room, easily visible and clearly reflect the locations of all the pertinent valves and pipes and the color coding for each.

Examples of two different types of legends:

PIPES

Return Line	=	**Blue**
Main Drain	=	**Red**
Skimmer	=	**Green**
Vacuum	=	**Orange**
Waste	=	**Black**

VALVES

When the system is on **FILTRATION:**
EVEN numbered valves are **OPEN ODD** numbered valves are **CLOSED**

When the system is on **BACKWASH:**
EVEN numbered valves are **CLOSED**
ODD numbered valves are **OPEN**

Either of these options provide sufficient information for a qualified pool operator to navigate the system quickly and easily. Either type can be used as long as the pump room is clean, organized, and well-marked. The valve legend needs to be accurate and includes all valves, pipes, etc.

Skimmers on the surface, drains on the bottom, and inlets on sides or bottom, all contribute to water motion and flow. If all are working correctly, the water throughout the body of the pool will be in constant motion.

AIR CIRCULATION

Air Handling System is equipment that brings in outdoor air into a building and removes air from a building for the purpose of introducing air with fewer contaminants and removing air with contaminants created while bathers are using aquatic venues. The system contains components that move and condition the air for temperature, humidity, and pressure control, and transport and distribute the air to prevent condensation, corrosion, and stratification, provide acceptable indoor air quality, and deliver outside air to the breathing zone.

The air system should maintain relative humidity between 40% and 60%. It should also keep the temperature ideally within 2 ºF (no more than 5 ºF) of the water temperature. The inability to maintain the appropriate humidity and temperature level promotes corrosion, poor air quality, mold, mildew, and bather discomfort.

Air return vent should be low to the floor to extract chloramines hovering above the surface of the water in order to improve air quality. Air system should be changing 4 to 8 times per hour depending on whether mechanical cooling are not

Fill in the chart with the range of each reading and the chemical name that raises and lowers each reading:

Chemical	Minimum	Maximum	Raise	Lower
Chlorine				
pH				
Total Alkalinity				
Calcium Hardness				
Cyanuric Acid				
Total Dissolved Solids	No Minimum		Not Applicable	

Filtration Systems

CHAPTER NINE

Chapter Objectives

1. List the three basic types of filters.
2. Identify how each filter operates properly.
3. To identify what can happen to a filter if it is improperly backwashed.
4. To explain why a below-ground filter system is easier to prime than an above-ground system.
5. To be able to perform the following equations:
    a. Pool volume for rectangular and circular pools
    b. Flow rate and turnover rate
    c. Square footage requirements for sand filters

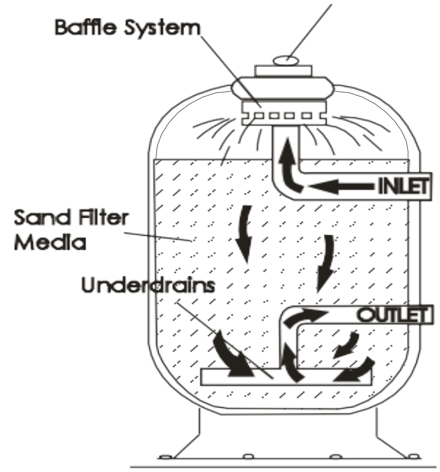
FILTRATION SYSTEMS

Filtration is the removal of small particulate matter. Maintaining good water clarity requires both disinfection and filtration of particulate matter. Neither disinfection nor filtration alone is sufficient. The size of the filter for a circulation system must be compatible with the pump capacity.

There are three main types of filters typically used in the aquatic industry: Sand, Diatomaceous Earth (DE) and Cartridge.

SAND FILTERS

Sand filters can typically filter particulate matter down to 20-40 microns. One micron is one-millionth of a meter (0.00004 inches). The human can see particles 40 microns or larger. Water comes into the filter through the filter's influent line (the top pipe) and is dispersed through the diffuser. The **diffuser** evenly distributes the water through the sand bed. The sand in a filter is # 20-grade filter sand. This grade of sand is the only grade of sand that should be used in the filter. Most manufacturers recommend that a layer of pea gravel be placed in the bottom of the tank to support the laterals. **Laterals** are the rungs located in the bottom of the filter tank that has very narrow slots in them. These slots allow the water to pass through but not the sand. A broken lateral can allow sand into the return lines and thus into the pool basin.



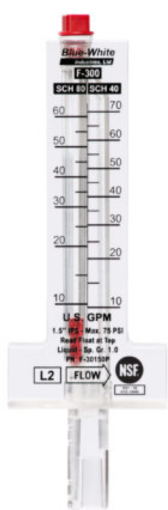
Backwash to Clean
High Rate Sand Filter

BACKWASHING SAND FILTERS

Backwashing is the process of reversing or redirecting the water flow through a sand filter for the purpose of cleaning the filter. Particulate matter accumulates in the filter bed and reduces the efficiency of the filter, therefore reducing water flow. Backwashing removes this particulate matter and sends it to waste.

There are two filters the determine when a filter should be backwashed:

1. **A decrease in the rate of flow**:
   The flow rate is the rate at which the water moves through the filtration system. There are minimum rate requirements to ensure that the water is moving at a sufficient rate in order to "turn over" the entire pool volume within a specified period of time. The flow rate is measured by a flowmeter, in GPM's (gallons per minute). The flowmeter is necessary to determine the effectiveness of the recirculation system. When the flow rate slows to a rate that is below the required level, the system needs to be backwashed. Flowmeters are sized depending on the pipe diameter and available in low or high flow increments. Some flowmeters have a small bead that floats or slides up and down on a scale to indicate the rate of flow. Others are digital.

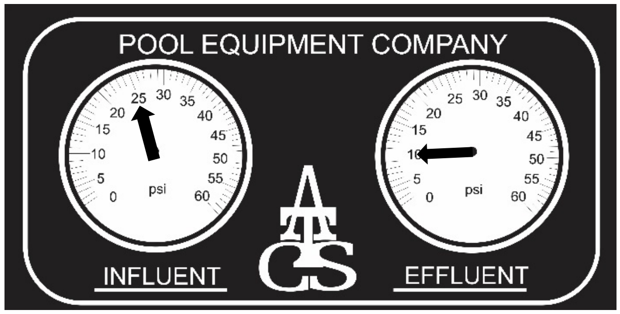


AS PRESSURE INCREASES,
FLOWRATE DECREASES!

Example of flowmeter

Example of a pressure gauge

2. **An excessive differential on the influent and effluent gauges:**
The influent and effluent gauges on the filter tanks read in PSI (Pounds per Square Inch). They measure the amount of pressure going into and coming out of the filter. Each filter must have an influent gauge, and each system must have an effluent gauge. When the difference between the pressure readings on these two gauges **exceeds 15 PSI**, the system should be backwashed. Your local Health Department may have regulations governing the minimum or maximum level of this differential.



FILTER RUN

A **filter run** is the time between backwashes. This time varies from pool to pool and can be affected by weather, bather load, and other various factors. Do not make a habit of backwashing daily or on a regular schedule. Backwash only when the system needs to be backwashed. A certain amount of build-up will help the filter work better.

Zeobrite is an alternative media to be used in a typical high rate sand filter as an alternative to sand. Pea gravel is not used with this product. It is a very tiny coarse rock. It fits very tightly together in the filter and is supposed to capture smaller particles than the #20-grade filter sand. It also is a salt activated product that helps reduce combined chlorine by absorbing ammonia and nitrogen compounds.

Every pool will be backwashed differently. Below are a few steps that will be necessary for most facilities and should be added to the site-specific facility backwash procedure chart. Many jurisdictions require a backwash procedure chart to be posted at each facility. This is a very specific chart with step-by-step procedures for backwashing the system. Be wary of pool builders that will post a generic backwash procedure chart upon completion of a pool.

1. Turn off the heater. Many pool heaters are required to be turned off prior to turning the system off for any reason. Some are required to be turned off up to 20 minutes before backwashing.
2. Turn on the fill water. The pool will lose water during the backwash procedure.
3. Turn off all chemical feeders.
4. Turn off the pool pump BEFORE turning any valves in the pump room.
5. Clean the hair and lint pot basket and CAREFULLY reseal the lid.
6. Always close the return line valve while backwashing.
7. Follow all manufacturer's instructions explicitly.

Manufacturers often recommend that sand filters be cleaned periodically using cleaners with detergents (for indoor facilities, clean every 3-6 months, and for outdoor pools, clean at the end of the season). Sodium Hydroxide is a common detergent used for this purpose.

Improper backwashing, backwashing too often, or having an old filter media can cause the following problems to develop within the sand filter:

1. Mudballs: Mudballs are sand particles held together by organic matter (hair, lint, body oil, body grease, suntan lotion, etc.). If allowed to continue accumulating, mudballs can produce weak spots in the filter bed and cause channeling. Sodium Hydroxide will dissolve mudballs and allow the dirt and other particles to be backwashed away.
2. Channeling: Channels or hollow tunnels form in the sand bed due to excessive mudballs and/or calcification. The water continues to flow through the filter by way of these hollow channels, but it is not properly filtered.

3. Calcification: A build-up of calcium compounds can cause the sand to become cemented together. This can happen when the water is flowing too fast through the filters. Old sand can also become calcified.
4. Crevicing: Crevicing happens when the sand bed shifts to one side of the tank, leaving a vacant area within the filter tank through which some of the pool water can pass without being properly filtered. A slip in the position of the diffuser can cause this to happen.

Sand is generally scheduled to be changed every 2-3 years in an indoor pool and every 7-8 years in an outdoor seasonal pool. This is called recharging the system. Sand has very sharp edges observed under a microscope. Over time, the sand particles lose their sharp edges, and they smooth, making it more difficult to catch small pieces of dirt.

There are 2 commonly used types of sand filters.

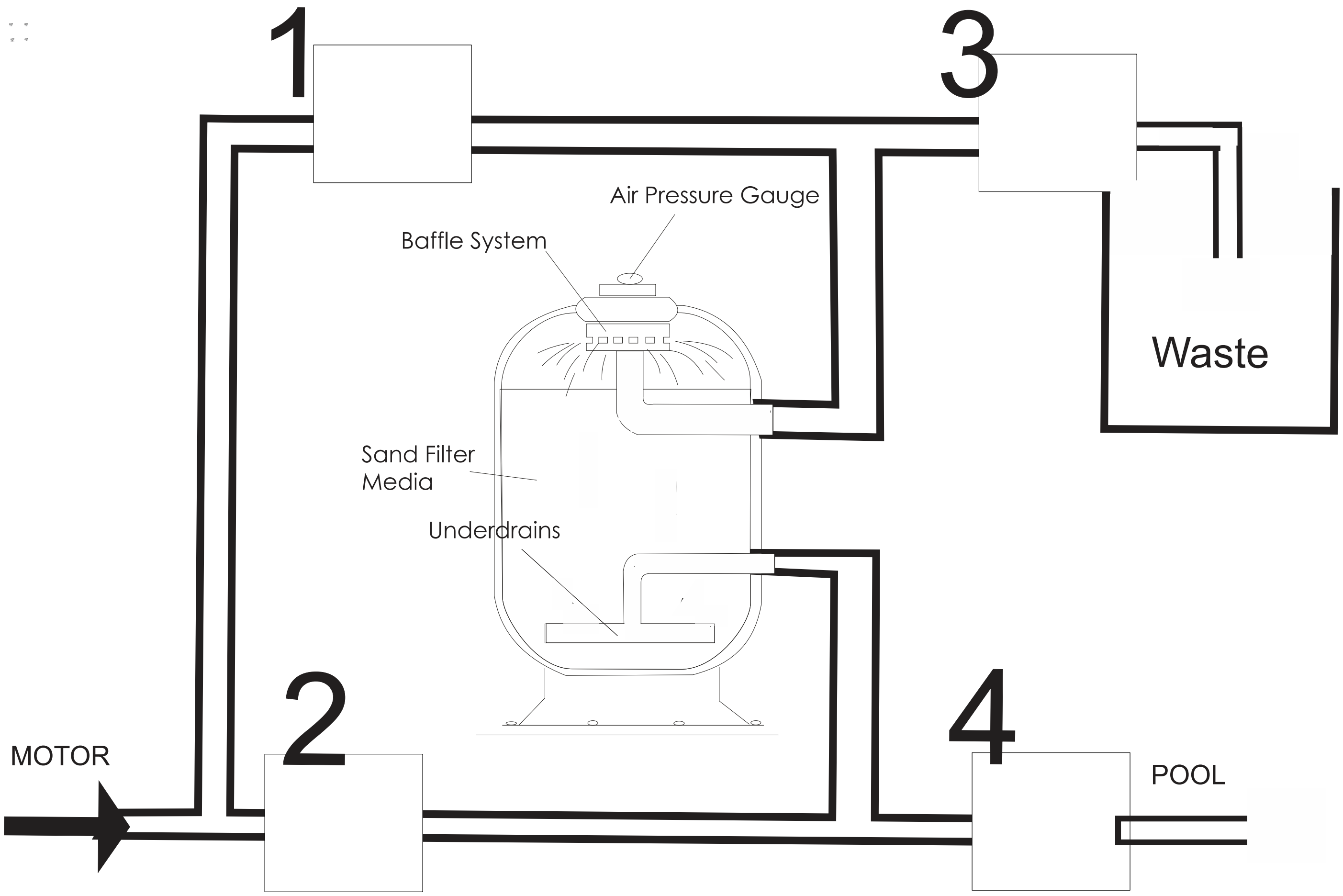
1. **Low (slow) Rate Sand Filters (LRS)**
   For every square foot of filter area, there are approximately 3 GPM (Gallons Per Minute) flowing through the filter. Usually, there is more than one filter. Three is the average, with the size of the tanks based on the size of the pool. LRS (Low Rate Sand) filters are backwashed one filter at a time because they need to be backwashed at 6-9 GPM/ sq. Ft.

2. **High Rate Sand Filters (HRS)**
   For every square foot of filter area, there are approximately 15 GPM (Gallons Per Minute) flowing through the filter (20 for residential-sized pools). HRS (High Rate Sand) filters are backwashed at the same time because they backwash at 156 GPM/sq. Ft.

Sometimes a coagulant or flocculent is used to aid a sand filter. A flocculent creates an additional layer on the filter bed that causes small pieces of dirt to stick together. Now that the dirt is bigger, the filter is able to remove the dirt. **Aluminum sulfate (alum) is the most commonly used flocculating agent.** A flocculent is only good for one filter run as it will be removed by backwashing.

ALWAYS follow manufacturer recommendations on use.
Polymer clarifying agents can also be used to aid a filter or help clear cloudy water. Some micro-contaminants can escape filtration even though the filter is operating properly. The micro-contaminants usually have a negative charge. The clarifying agents are positively charged so that they attract and connect with the negatively charged ions, making them larger so they can be filtered out.

Here is a typical layout of a sand filter system. It does not matter how many tanks the system has. Keep in mind, each system has its own numbering system for its legend.



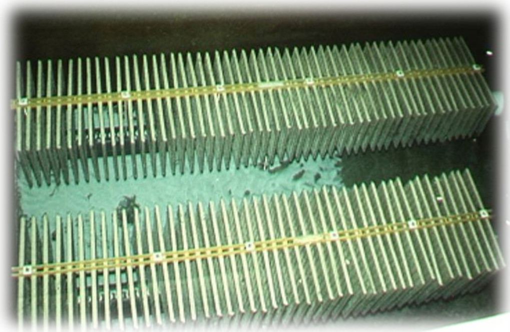
A legend will be provided in the pump room that identifies what valves need to be open and closed to perform the following tasks:

	OPEN	CLOSED
Filter:	**1,4**	**2,3**
Backwash:	**2,3**	**1,4**
Drain:	**1,3**	**2,4**
Bypass Filtration (to prime):	**2,4**	**1,3**

Multi-port valves are used on smaller systems and can set the filter system to filter, backwash, and drain in the turn of a handle. It is important to always turn off the pump before turning the handle. It is usually a good idea to put the system in the rinse for a few moments after backwashing before placing the system back into the filter.

DIATOMACEOUS EARTH (D.E.) FILTERS

Diatomaceous Earth (D.E.) Filters are no longer commonly used but have excellent filtering capacity. D.E. is the porous fossil remains of diatoms (sea algae). These fossils are so small and pack so tightly that they make an excellent filter media. The D.E. particles act as the filter by trapping particulate matter. They can filter down to approximately 7 microns. D.E. filters come in a variety of different shapes and sizes. Systems can be either open or closed. Closed systems can be cylinder-shaped stainless-steel tanks. The open-pit D.E. filters are rectangular or square "pits" on the floor or "tub-like" above ground.



These systems work under pressure or by a vacuum. This depends on how the system was built and how it is plumbed. The D.E. powder is placed in a feeding device or is fed through the skimmer and attaches to the filter elements. The elements consist of plastic or metal ribs covered by a woven material. The type of material or fabric can vary depending on the specific filter design. The D.E. powder is held to the material by the pressure or vacuum created within the filter when the system is running. Therefore, when the system turns off, the D.E. powder will fall off of the elements. For filtration to continue effectively, the D.E. powder will need to be "bumped" back onto the elements. This is usually done with a handle that simply stirs up the powder as the system is turned back on, allowing it to reattach to the elements.

The elements themselves are not an effective filter unless they are thoroughly coated with Diatomaceous Earth on both the front and the back. Any break in the material will result in D.E powder being carried back to the pool.

To get D.E into the filter:
PRE-COAT POT: A one-shot deal between filter runs. The entire amount that the filter holds is added all at once. It thoroughly coats all the elements and, unless the system goes off for any reason, it will remain there until the filter run is over and needs to be cleaned. (See "Cleaning D.E filters" below) The elements should be precoated with **2 ounces of D.E. per square foot of filter surface area.** Do not forget to count the front and the back of the element when calculating the total surface area of the element.

SLURRY FEEDER: The D.E is also added slowly during the filter run. By the end of the filter run, the elements will have the D.E. "caked on." This makes them a little harder to clean, but it also extends the filter run, and, some say, this method allows the filter to work even better. The downfall can be that the "caked on" Diatomaceous Earth is very difficult to remove for cleaning.

To Clean a D.E filter:
Like a sand filter, every tank and system has its own specific cleaning procedures. This is a general guideline to help make a proper and complete filter cleaning checklist.

- Clean all skimmer baskets
- Turn off all chemical feeders
- Turn off the system (this will allow the D.E to fall to the bottom of the filter tank)
- Wash off the elements and REMOVE the D.E from the tank (it is thrown away)**
- Clean elements and replace OR put a second set of elements in and soak the dirty one in a cleaning solution to degrease it
- Pre-coat or Slurry feed the D.E back into the filter and resume operation
- Turn on all chemical feeders

Be careful to remove all D.E from the filter elements and degrease the elements. A build-up of oil and grease on the elements can cause the pool water to be ineffectively filtered, and it will get cloudy.
** Check the local Health Department regulations for requirements on the dumping of D.E.

Unlike the sand filter system, D.E systems can be quite costly (constantly replacing the D.E.), and some of them can be difficult to operate effectively. D.E. systems will require in-service training until the operator feels comfortable with its operation.

CARTRIDGE FILTERS

Cartridge Filters removes particulate matter by straining water through the fabric material of the cartridge. These filters have the capacity to filter particulate matter down to about 20 microns. They are cylindrical shaped elements with a cloth-like fabric covering "accordion-folded" around the cylinder. When the filter run is complete, and the cartridge needs to be cleaned, the best way is to remove it, hose off the debris and soak the cartridge in a special cleaning product. It can then be replaced.

It is beneficial to have a second set of cartridges for the filter, so one set can be in place and filtering, while the other is being cleaned. Well cared for cartridges can last for a few years, depending on the number of cleanings due to pool use, etc.

CALCULATIONS

FORMULAS FOR POOL CAPACITY

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)

SURFACE AREA

Rectangular pool = L x W Circular pool = r² x π Right triangle = (L x W) ÷ 2

AVERAGE DEPTH

For constant slope: [D (minimum) + D (maximum)] ÷ 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 Circular pool V = r² x π x D

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

Rectangular pool gallons = L x W x D x 7.5 Circular pool gallons = r² x π x average D x 7.5

TURNOVER RATE

Pool Volume / Flow rate / 60 = Hours

FLOW RATE (MINIMUM)

Pool Volume / Turnover Rate (hours) / 60 = Gallons per Minute

FILTER SURFACE AREA

Flow rate / Filtering Ability = Sq Feet of Filter Surface Area Needed

FILTER FLOW CAPACITY

Filter Area x Filtering Ability x Required Turnover x 60 = Filter Flow Capacity

MAXIMUM USER CAPACITY

Surface Area / Health code bather capacity = Max User Capacity

Quick Reference Conversion Table

Ounces to Pounds Ounces ÷ 16 = Pounds	Milliliters to Liters Milliliters ÷ 1000 = Liters
Fluid Ounces to Gallons Fluid Ounces ÷ 128 = Gallons	Meters to Feet Meters x 3.28 = Feet
Liters to Gallons Liters ÷ 3.785 = Gallons	Fluid Ounce to Milliliters Fluid Ounce x 29.57 = Milliliters
Fluid Ounces to Cups Fluid Ounces ÷ 8 = Cups	Celsius (°C) to Fahrenheit (°F) °F = (9/5 x °C) + 32
Yards to Feet Yards x 3 = Feet	Fahrenheit (°F) to Celsius (°C) °C = 5/9 x (°F - 32)
Cubic Feet to Gallons Cubic Feet x 7.48 = Gallons	Quarts to Gallons Quarts ÷ 4 = Gallons

EXAMPLE 1: Rectangle Pool Volume & Flowrate

Length of pool: 75 Feet
Width of pool: 50 Feet
Shallow End Depth: 3 Feet
Deep End Depth: 5 Feet
Turnover Rate: 6 Hours

Volume of pool in gallons: Length x Width x Average Depth x 7.5
Volume of pool in gallons: 75 x 50 x 4 x 7.5 = 112,500 gallons

Minimum Flowrate of pool in gpm: Volume ÷ Turnover Rate ÷ 60
Minimum Flowrate of pool in gpm: 112,500 ÷ 6 ÷ 60 = 312.5 gpm

EXAMPLE 2: Circular Pool Volume & Flowrate

Diameter of pool: 8 Feet
Shallow End Depth: 3 Feet
Deep End Depth: 4 Feet
Turnover Rate: 30 Minutes

Volume of pool in gallons: Radius x Radius x 3.14 x Average Depth x 7.5
Volume of pool in gallons: 4 x 4 x 3.14 x 3.5 x 7.5 = 1319 gallons

Minimum Flowrate of pool in gpm: Volume ÷ Turnover Rate ÷ 60
Minimum Flowrate of pool in gpm: 1310 ÷ 30 = 44 gpm

Remember: The flow rate is the rate at which the water moves through the filtration system. There are minimum rate requirements to ensure that the water is moving at sufficient speed in order to "turn over" the entire pool volume within a specified period of time. The rate is measured by the flowmeter in gallons per minute. The flow rate is dependent on the size of the piping, the size of the pump, the size of the impeller, and the horsepower of the motor. As any of these factors increase, the flow will increase.

EXAMPLE 3: Current Turnover Rate

Volume of pool:	150,000
Current Flowrate:	350 gpm

Turnover Rate in hours:	Volume of Pool ÷ Current Flowrate ÷ 60
Turnover Rate in hours:	150,000 ÷ 350 ÷ 60 = 7.14 hours

Spa Maintenance

CHAPTER TEN

Chapter Objectives

1. To identify some problems that relate specifically to spas.
2. To identify several factors that are good critical for good spa maintenance.
3. To determine why Bromine is a better disinfectant in spa water.

SPA MAINTENANCE

Spas can be a tremendous source of enjoyment for people. Many people who have spas in their homes have very little trouble taking care of it. However, spas in commercial locations that get a great deal of use can be very difficult to maintain. The small body of water, and the fact that the patrons sit and sweat, makes the water chemistry hard to keep in the proper ranges.

Here's something to consider: For every person that gets into a spa for 15 minutes, up to a quart of body fluid can be excreted. This foam is a build-up of the TDS level, as discussed in chapter 2. When an excess of foam appears in the spa, it is time to drain it. How often a spa should be drained varies. It largely depends on the bather load of the spa. A general rule is to divide the number of gallons of water that the spa holds by 3, and when that number of people have used the spa, it is time to drain and refill.

For example, take an 800-gallon spa and divide it by 3 = 267. After about 267 people get into the spa, it is time to drain. Four people in a 500-gallon spa are equal to about 160 people in a 20,000-gallon pool.

Taking a casual attitude toward maintenance and safety standards can quickly produce an unhealthy environment.

Pseudomonas is a problem sometimes found in pools, but more often found in spas. It is a bacterium that thrives in warm water. If the disinfectant level drops below the recommended standard, the bacteria can develop, especially in the jet lines. Since the jet lines sit idle when the spa is not in use, this is a prime area for the pseudomonas to thrive. If a white cloud appears to be coming out of the jet line in the morning, or after sitting idle, the spa may be infested with pseudomonas. At this point, it needs to be drained and cleaned.

There are typically two sets of returns for a spa. One set for the circulation system and the other set for the hydrotherapy (blower). There could even be a third set, if the spa has two sets of hydrotherapy jets. Many spas are concrete or have an acrylic-based shell. In acrylic shells, there are usually air channels on the floors and seats. Flexible PVC pipe is set in place when the shell is formed and is molded there. When the shell cools, holes are drilled through this pipe and a blower is installed to blow air through the holes.

Water chemistry and disinfection is critical to proper spa maintenance.

A few specific problems to spas are:

1. Higher temperatures can cause the following:
   a. Surface scum and users' fats and body oils, which are hard to oxidize, can cause a "bath-tub" ring. This can contribute to filter dirtiness quickly. A filter cleanser such as Tri-Sodium phosphate should be used regularly to clean the oils, etc. out of the filter.
   b. Increased disinfectant demand with much quicker dissipation.
   c. Faster evaporation of the water (adding more water requires more chemicals).
   d. Solids build-up. The build-up of TDS can cause excessive foaming. Aeration will cause "bubbling," which is different from the foam build-up.
   e. Hard to control pH. The bathers perspire due to the heat, and the sweat causes an increase in pH.

2. Due to its small volume of water, adding chemicals can present its own problems. When adjusting chemical levels, remember to double-check the number of gallons and add chemicals in VERY small amounts, retest, and add more if needed.

3. Heating problems can be created.
   a. Always remember to turn off the heater when turning off the circulation system for any reason. The heating elements can be damaged if the heater is left on when the water is not circulating.
   b. Using a cover at night or when the spa is closed will help retain heat and help cut down on evaporation.
   c. Be familiar with the local Health Department regulation for temperature maximum. It is usually 104°.

4. Safety Concerns may develop. Check with the local Health Department for specific regulations on spa safety and required signs that need to be posted. General rules that should be enforced along with the Health Department regulations and house rules are listed below:
   a. The use of the spa should be no longer than 15 minutes at a time. Blowers should be on a timer with a maximum of 15 minutes and should be out of reach of patrons using the spa.
   b. NO ALCOHOL.
   c. Persons with high blood pressure, elderly, children, and pregnant women should consult a physician before using the spa.
   d. Children under the age of five should not use the spa. (Most jurisdictions require higher disinfectant levels, and the higher temperatures can pose a health risk for young children. Many children tend to "swim" around and not just sit and relax. This movement can raise body temperature even higher).

Good Spa Water maintenance depends on the following:

1. A diligent and informed pool operator.
2. Effective filtration and rapid water turnover (30 minutes or less).
3. Regular backwashing and cleaning of the filter.
4. Regular emptying, cleaning, and refilling of the spa.
5. Proper "chemical balance" of the water.
6. Constant disinfectant residual, in the proper ranges.
7. Daily "shock treatment."
8. Daily cleaning of scum line.
9. Use de-foamers only occasionally. They "melt" the bubbles, but do not solve the problem as to why the bubbles are appearing.

The following qualities make Bromine a better disinfectant in spa water:

1. Bromine is more stable than chlorine at higher temperatures
2. Combined bromine (bromamines) provide disinfection where combined chlorine (chloramines) does not.
3. Bromine is effective over a wider pH range
4. Combined bromine arguably has less of a disagreeable odor than combined chlorine.
5. Combined bromine eliminates some bather discomfort, which can be caused by combined chlorine.

No matter what type of filtration, type of disinfectant, or the bather load, a spa MUST be well-maintained by an operator who is continuously on top of the needs of the water and tends to them immediately. Even with an automatic system, a spa needs hands-on maintenance regularly.

CHAPTER ELEVEN

Chemical Safety

Chapter Objectives

1. To list some information that container labels contain.
2. To identify safe storage procedures for pump room chemicals.
3. To identify safe procedures for handling chemicals in the filter room.
4. To describe the proper method for adding chemicals to a pool.
5. To identify safety equipment, all pump rooms should contain.

CHEMICAL SAFETY

Many chemical safety hazards exist in the aquatic environment. TAKE PRECAUTIONS AT ALL TIMES!

Many of the chemicals used in a pool pump room are either corrosives or oxidizers.

Corrosion: To consume away gradually by chemical action

Oxidizers: Contact with heat, moisture, or foreign materials may result in fire

All containers in the pump room must have the original container label on them. Never put a chemical into an unlabeled container!

Container labels should contain the following information:

- Identity of the chemical
- Reactivity of the chemical
- First Aid procedures
- Personal safety warnings, (i.e., do not breathe dust, use in a ventilated area, use goggles, gloves, splash apron, and respirator)
- Name and address of the manufacturer
- All containers must have labels prominently affixed and shall provide chemical name and hazard warnings

When a chemical order is received, everything must be labeled correctly. Check to be sure the lids are airtight, and the container is not damaged. Always read warning labels on chemical containers.

SAFETY DATA SHEETS

Safety Data Sheets, often referred to as Material Safety Data Sheet (MSDS), are informational sheets on chemicals. Always read the entire MSDS, especially the first aid section. Keep the MSDS in an easy to access area and periodically make sure that all chemicals have sheets. This includes testing reagents, cleaning products, and anything that is used or stored within the pool enclosure. The chemical company or store where the products are purchased must supply the MSDS.

There is no specific form required. However, they must contain the following information:

1. Manufacturers name, address, and emergency phone numbers
2. Formal chemical and common (trade) names
   Ex: Calcium Hypochlorite: HTH or Chloryte
3. All types of information that concern public health officials, fire/rescue personnel and physicians in the event of an emergency.
4. Information important to the aquatics professional:
   a. Chemical and common names
   b. Chemical family, i.e., halogens
   c. Health hazard data and emergency first aid
   d. Reactive data: WHAT CHEMICALS ARE INCOMPATIBLE and could produce a reaction
   e. Fire and explosion data
   f. Spill and leak procedures
   g. Protection information for the user: (gloves, goggles, etc.)

MSDS should also be located in a RIGHT TO KNOW area at each facility. This area needs to be accessible to the pool patrons and should contain any information that is pertinent to the community. SARA Title III: The Community Right to Know, assures the community has the right to know any and everything about the pool, the chemicals, the readings, etc. OSHA requires this area to be kept up-to-date and informational and will inspect this area on a routine inspection.

The local Health Department may also ask to see all MSDS on a routine inspection.

OSHA also requires all pool operators to be site-specific trained in the handling, storage, etc. of the chemicals. These pool operators must sign and date a form (it can be a generically typed form) stating that this training has taken place. These forms must be kept on file for 40 years and available for an OSHA inspection.

Storage and Handling of Chemicals in the Pump Room

STORAGE

1. Always keep the door locked but have the key easily accessible in case of an emergency.
2. Keep bags of chemicals off the floor. Keeping the bags of bulk chemicals in small trash cans with a lockable lid is a great way to keep the pump room cleaned and organized and will keep the chemicals dry. Also, laminate or put in a plastic sheet cover, the MSDS for that product, and tape it to the container. Your chemical room will be less hazardous if the chemicals are securely stored, and the MSDS will be readily accessible if needed.
3. Make sure containers are covered with the original top.
   a. All chemicals should be kept in their original container (especially oxidizers) or a marked container that includes the MSDS sheet attached to it.
   b. Sodium and acid vats are to be kept covered and as far away from each other as possible. Try not to have these vats sitting directly under the chemical feeders, as it will cause them to corrode easily.
   c. All containers are properly labeled and contain the original chemical.
   d. Dust covers on all CORROSIVE materials; they will easily corrode metals.
4. Keep different chemicals away from each other (ex: Chlorines and acids).
   a. Store alike chemicals together.
   b. Have a separate storage area for cleaners, etc.
5. Always keep the pump/chemical room clean, organized, and locked. Always clean up spills immediately.

HANDLING CHEMICALS IN THE FILTER ROOM

1. Good air ventilation is a must.
2. Safety equipment: gloves, goggles, splash apron, and respirator must be located within the filter room.
3. NEVER MIX DIFFERENT CHEMICALS TOGETHER.
4. ALWAYS ADD CHEMICALS TO WATER, NEVER WATER TO CHEMICAL.
5. If adding a dry chemical, broadcast downwind.
6. Always wash hands after adding chemicals.
7. Always wear shoes in the filter room.

ADDING CHEMICALS TO THE POOL

1. After putting on the proper safety equipment, put water into a plastic bucket (not metal). Always add the chemical to water (stir until dissolved) and, unless otherwise directed, pour around the pool's perimeter. Note: Do not use metal to mix the chemicals. Use a wooden or plastic spoon or handle.
2. Never add any chemical while the pool is in use.
3. Never pour chemicals into the skimmer, unless specifically directed by the manufacturer. This sends a strong concentration directly to the pump and can damage the motor.
4. Read MSDS on all chemicals before adding and always read the manufacturer's recommendations for the correct method of adding.

IN THE EVENT OF A CHEMICAL SPILL

Refer to Appendix B for further information

1. Keep all patrons and staff safe!
2. Close off the area.
3. Evacuate if fumes are present.
4. Call 911, if fumes are present OR if someone is injured.
5. Consult your Materials Safety Data Sheets.
6. If the spill is minor and dry, sweep it up carefully and replace in the original container or dispose of it.
7. If the spill is minor and liquid, dilute the area WELL with water.

Chemical Safety Review Key Points
Chemical Safety Guidelines

These guidelines are steps that can be followed to minimize your risk of being injured by potentially hazardous chemicals at your workplace.

- Always wear personal protective equipment, including gloves, goggles, an apron, and safety shoes. Unless exposed to bloodborne pathogens, used personal protective equipment may be discarded with the trash.
- Properly store all chemicals when not in use.
- Never mix chemicals with any substance other than water. Mixing a full-strength acid with chlorine will release toxic chlorine gas.
- When priming a chemical feeder, always point the hose away from the eyes and face.
- Never store chemicals in anything other than their original container.
- Take proper precautions and understand the hazards of working with pool chemicals.
- Wash hands before eating, drinking, smoking, and leaving the worksite.

All pools need chemicals to keep them sanitary and safe according to health department standards. Exercise extreme caution when working with chemicals. Chemicals must be used properly to ensure the safety of staff and patrons.

There are many factors that influence the level of toxicity, including concentration, entry route, duration of exposure, and frequency of exposure. Individuals may be exposed to chemicals through inhalation, skin contact/absorption, injection, and ingestion. The body may respond immediately with acute effects or chronic effects that may occur years later. Lifeguards must use their senses to detect hazards. Be aware of eye irritation, odors, visible clouds of dust or fumes, and leaks or spills.

There is valuable written information on hazardous chemical containers. Labels provide the product name, chemical ingredients, and hazard warnings. CIS (Chemical Information Sheets) provides an inventory of all hazardous chemicals used at a job site. MSDS (Material Safety Data Sheets) contains a wealth of information including product name, chemical ingredients, health hazards, personal protective equipment, safe exposure limits, spill/fire/emergency information, and handling/storage/disposal information.

Only professional swimming pool operators are trained to handle chemicals. Therefore, staff not certified as a pool operator should at no time handle chemicals at the pool. ATCS encourages all lifeguards to further educate themselves on chemical safety by becoming certified operators. Staff should never, under any circumstances, mix chemicals.

All chemicals used for pool sanitation should be stored in a well-ventilated area and inside clearly marked containers. Improper storage of chemicals presents a danger to all who encounter them, especially curious children. The use and storage of hazardous chemical products in the workplace can expose workers to a variety of physical and health hazards.

Physical Hazards	**Health Hazard**	
-Flammable	-Poisons	-Carcinogens
-Reactive	-Asphyxiates	-Reproductive Toxins
-Oxidation	-Corrosives	-Liver Toxins
-Radioactive	-Irritants	-Kidney Toxins
-Biohazards	-Sensitizers	-Neurotoxins
-Toxic	-Anesthetics	-Blood and Blood-forming Organ Toxin

CHAPTER TWELVE

Maintenance and Operations

Swimming Pools and Spas

Chapter Objectives

1. Understand the procedure to open a pool in the spring.
2. Understand the procedure to close a pool in the fall.
3. Identify the maintenance procedures necessary for daily, weekly, monthly, and/or annual care of an aquatic facility.

MAINTENANCE AND OPERATIONS OF SWIMMING POOLS

Visual and manual inspections of the pool, equipment, and environment need to be completed every day. A checklist to be initialed by the staff when the inspections are completed is the best way to keep track of needed maintenance and supplies. Note any unusual findings such as acts of vandalism or broken equipment, etc.

TYPE OF AQUATIC VENUES

1. Flat Water aquatic venues are where the water line is static except for movement made by users usually as a horizontal use as in swimming.
2. Agitated Water aquatic venues where aquatic features discharge, spray, or move the water's surface above and/or below the static water line through mechanical means. In these venues, people are standing or playing vertically.
3. Hot Water aquatic venues are where the water temperature is maintained over 90o F (32o C).

CLASSIFICATIONS OF SWIMMING POOLS

- Class A: Private swimming pools that service a residential or group home.
- Class B: Public pool that is intended for recreational use.
- Class C: Semi-public pool that is intended for use by a closed group such as a condominium association or hotel.
- Class D: Special-use swimming pool that usually has aquatic features such as a waterpark or wave pool.
- Class E: Therapy pool that is not for recreation and is usually hot water.
- Class F: Wading pool is very shallow water and is referred to as a “Kiddie” or “Baby” pool.

BARRIERS

All aquatic facilities must enclose their chemical and mechanical spaces to prevent access from the public. These enclosures could include walls or fencing that is at least six feet high. These enclosures cannot impede patron accessibility to the swimming pool, locker rooms, or exit areas. All doors and gates that provide barriers in the facility must have self-latching gates. All emergency exit areas need to be well marked and unencumbered.

SIGNAGE & MARKERS

Signage is extremely important at facilities. Signage that is required at all pools include:

-Emergency phone instructions
-Unauthorized area signs
-Chemical danger signs
-Variable water depth signs
-First aid location
-Management contact information
-Hours of operations
-Pool rules

All swimming pools must have water depths clearly marked. Permanent depth markers must indicate the minimum and maximum depth on both sides of the pool and at the break in the floor slope where the pool goes from shallow to deep. Depth marking should be on the tile line, coping stones, and/or printed on the deck and shall be no more than 25 feet apart. For shallow water (less than five feet), the depth should be marked as the pool gets each foot deeper. In addition, all areas that are less than 5 feet deep must be marked with "No Diving" markers.

EMERGENCY RESPONSE PLAN

Each facility should have their Emergency Action Plan and Emergency Call Script posted.

RECORD KEEPING

Record keeping including the need to keep accurate and timely records of the following areas:

- Operational conditions (e.g., water chemistry, water temperature, filter pressure differential, flow meter reading, and water clarity).
- Maintenance performed (e.g., backwashing, change of equipment).
- Incidents and response (e.g., fecal incidents in the water and injuries).
- Staff training and attendance.

DAILY OPENING PROCEDURES

The Professional Swimming Pool Operator shall ensure that a daily facility preventive maintenance inspection is done before opening and that includes:

1) Drain covers, vacuum fitting covers, SKIMMER equalizer covers, and any other suction outlet covers are in place, secure, and unbroken.
2) Skimmer baskets, weirs, lids, flow adjusters, and suction outlets are free of any blockage.
3) Inlet and return covers and any other fittings are in place, secure, and unbroken.
4) Safety warning signs and other signage are in place and in good repair.
5) Entrapment prevention systems are operational.
6) Recirculation, disinfection systems, controller(s), and probes are operating as required.
7) Underwater lights and other lighting are intact with no exposed wires or water in lights.
8) Slime and biofilm have been removed from accessible surfaces of the pool.
9) Doors to nonpublic areas (chemical storage spaces, offices, etc.) Are locked.
10) Fecal/vomit/blood incident contamination response protocols, materials, and equipment are available.
11) Electrical devices are in good working condition.
12) Water clarity is such that the bottom and objects on the bottom of the pool are clearly visible.

ROUTINE OPERATION CONSIDERATIONS

The Professional Swimming Pool Operator shall devise a daily and weekly inspection plan that includes but is not limited to the following:

1) Walkways/deck and exits are clear, clean, and free of debris.
2) Drain covers, vacuum fitting covers, skimmer equalizer covers, and any other suction outlet covers are in place, secure, and unbroken.
3) Skimmer baskets, weirs, lids, flow adjusters, and suction outlets are free of any blockage.
4) Inlet and return covers and any other fittings are in place, secure, and unbroken.
5) Safety warning signs and other signage are in place and in good repair.
6) Entrapment prevention systems are operational.
7) Recirculation, disinfection systems, controller(s), and probes are operating as required.
8) Secondary disinfection systems and/or supplemental treatment systems are operating as required.
9) Underwater lights and other lighting are intact with no exposed wires or water in lights.
10) Slime and biofilm have been removed from accessible surfaces of aquatic venue, slides, and other aquatic features.
11) Doors to nonpublic areas (chemical storage spaces, offices, etc.) are locked.
12) First aid supplies are stocked.
13) Emergency communication equipment and systems are operational.
14) Fecal/vomit/blood incident contamination response protocols, materials, and equipment are available.
15) Aquatic features and amenities are functioning in accordance with the manufacturer's recommendations.
16) Fencing/barriers, gates, and self-latching or other locks are tested and are intact and functioning properly, and barriers do not have nearby furniture to encourage climbing.
17) Drinking fountains are clean and in functional condition.
18) Electrical devices are in good working condition.
19) Alarms, if required, are tested and functioning properly.
20) Assessing glare conditions throughout operating hours to assess whether the bottom and objects in the pool are clearly visible.
21) Play structures and diving boards are in good condition.
22) Safety equipment as required by this code is in good condition, properly secured, accessible for intended use, and shall include at a minimum: a. Emergency Action Plan and emergency phone numbers, b. Rescue tubes, c. Resuscitation masks with one-way valve, d. First aid kits, e. AEDs, f. Emergency oxygen, g. Backboard, head immobilizer, straps, and h. Lifeguard stands.
23) Emergency shut-off systems (slides, water features, pumps, etc.) function properly.
24) Depth markings are clearly visible.
25) Lifelines and buoys are in place and in good working order.
26) Ladders are non-slip and rungs secured tightly.
27) Waterslides are in functional, safe condition.
28) Moveable fulcrum is adjusted properly to control spring in the board as necessary.
29) Moveable starting platforms are properly stored.
30) Access to permanent starting platforms is restricted or controlled when not in use by swim teams and prohibited when not in use by competitive swimming or swimming practice that is under direct supervision of an instructor or coach.
31) Railings are secure.
32) SVRS is functioning according to manufacturer's guidelines.
33) Skimmer baskets and covers are clean and in place.
34) Water quality and clarity is according to code.
35) Water level is appropriate.
36) Pumps retain the appropriate pressure.
37) Play structures are secure (consider water velocity and reference manufacturers recommended levels).
38) Verify required documentation and records are in place and signed by the appropriate personnel.
39) Soap dispensers in lavatories and showers are functional and supplied with soap.

OPENING POOLS FOR THE SEASON

Every pool is different, and jurisdictional Health Department regulations vary. The following is simply a guideline to help direct the process of preparing the pool for the season. Allow plenty of time. When setting the opening schedule, allow extra days for things to go wrong, because they will. If painting or caulking, or having other work completed, allow plenty of time for weather and the proper drying time without having to rush at the last minute.

A. Before beginning the Draining and Cleaning process, be sure to do the following:

1. Contact the Health Department to obtain the annual application and schedule the pre-opening inspection.
2. Arrange for water, electricity, and phone to be turned on.
3. Arrange for any other inspections the local Health Department may require (i.e., electrical or plumbing).
4. Check for winter damage.
5. Order needed chemicals, bathhouses, and cleaning supplies.
6. Assemble filter room.

B. Draining and Cleaning the Pool

1. Remove, clean, dry, and fold the cover and store properly. DO NOT put away while still wet.
2. Drain pool totally. Be careful if the sun is out and/or the weather is hot; DO NOT allow algae to remain on the sides of the pool and dry. Hose the pool walls down while the pool drains, and the algae is still wet. Send water to an appropriate place. Some jurisdictions require notification before draining a pool. Call the local public works department for instructions.
3. Flush skimmer line from the pump room through the hair and lint pot. Do this before or while the pool is draining.
4. Acid-wash the pool. Use diluted Muriatic Acid to brush walls and bottom. This can be done while the pool is draining. DO NOT allow acid to touch metal parts and DO NOT allow a puddle to form at the bottom of the pool if this is done after the pool is drained. Use Soda Ash to help keep the water from becoming too acidic. Straight acid can be used on stubborn spots, but DO NOT allow it to sit too long. Always RINSE the surfaces very well!
5. Remove and clean the main drain grate. Be sure to securely replace the grate. If the screws need to be replaced, be sure to order manufacturer screws ONLY to prevent the drain from becoming loose and causing a suction entrapment hazard.
6. Clean out all inlet and vacuum fittings, fill spouts, and ladders (replace all bumpers).
7. Paint, caulk, etc. as needed. If painting, be sure to read directions and follow explicitly. Order the same kind of paint that has been used in the past and watch the weather for rain forecast. Plan accordingly. Allow the paint to dry the recommended amount of time to prevent future problems.
8. Replace all plugs, gauges, meters, etc. in the pump room. Open filters and check the media. Clean and/or fill as needed.
9. Clean the insides of skimmers and replace missing or broken weirs, baskets, and/or lids.
10. Clean the tile line.
11. Fill Pool. A sequestering agent should be added as the pool fills.
12. Connect all plumbing in the bathhouse and clean.
13. Put out all deck furniture, hose and/or scrub as needed.
14. Once the pool is filled, PRIME PUMP and start system.
15. Balance pool: Alkalinity, Calcium Hardness, and pH. Begin adding Cyanuric Acid.
16. Begin adding disinfectant. Shock the pool just before opening day.
17. The pool will need to be vacuumed and brushed daily for several days.
18. Backwash as needed.
19. Put up boards, guard chairs, and ladders, etc.
20. Pass the pre-opening inspection.

CLOSING POOLS FOR THE SEASON

A little extra time and care while closing will make opening next year a lot easier and cut down on replacement and maintenance costs. Again, every facility is different.

This is a guideline to help direct the closing process.

1. Before shutting down the pump, drop pH to about 7.2 and run remaining chlorine into the pool.
2. Run clear water through chlorinator, then a weak acid solution, and then more water to thoroughly clean it before taking it apart for the winter. See appendix B. Drain and coil tubing. Throw feed tubes away. Replace in the spring.
3. Add algaecide and allow to circulate throughout the pool. Check the algaecide directions carefully. Some algaecide treatments must have the chlorine level in a certain range.
4. Clean filters with a filter cleaner.
5. Backwash thoroughly. The pool should be drained several inches below the tile line. DO NOT drain water below the level of the lights, if the pool has wet-niche lights.

WET-NICHE lights are lights that are located within the pool (compared to dry-niche lights, which actually are outside of the pool). **NEVER turn a wet-niche light on when it is not in water**. The water of the pool is used to cool the light. If the glass is not wet, the light can explode.

To change a wet-niche light bulb:

- Turn off the breaker.
- Remove the light from the pool (most lights are held in by one screw). The light will have about a 6' cord on it that will allow it to be placed on the deck.
- Carefully remove the globe. Once the globe is removed, take the bulb out.
- Replace the bulb with the same wattage and voltage of the one that is in there.
- Be sure the inside is dry before replacing the globe. Also, check the gasket. Be sure it is not dry and cracked. If it is, it needs to be replaced.
- Carefully put the gasket and globe back together. Make sure it is on tight and test it in a bucket of water BEFORE putting in back in place.

6. Clean and organize the bathhouse. After turning off the main water supply line, flush toilets twice, and urinals six times, and open all valves to sinks and showers.
7. Remove floats and baskets from skimmers (not weirs).
8. Replace all screw eyes, vacuum holes, etc. with solid covers.
9. Have all snack machines etc. removed to prevent vandalism.
10. Grease all exposed ferrous metals.
11. Grease all valve stems and anything that moves.
12. Remove ladders, grease all hardware, and remove bumpers. Putting a light coat of wax on the ladder will help it shine in the spring.
13. Clean and organize the pump room. Tightly secure and properly store all leftover chemicals. Remove all plugs, gauges, etc. Store them where they can be easily found in the spring. Drain the pump (most pumps have two plugs, one at the hair strainer, and the other in the pump. Both must both be removed).
14. Drain skimmer line (use a shop-vac to suck the water out of the skimmer lines, or compressor to blow the water out of the line).
15. Put pool antifreeze into the skimmers. 1 gallon per skimmer is recommended. Put winterization plugs into the skimmer and then put the empty jug of anti-freeze into the skimmer OR use a gizmo to do both jobs.
16. Clean and store all ropes, hoses, and equipment.
17. For those facilities with an automatic chemical feeder, the probes must be removed and stored in the manufacturer-supplied containers so as not to dry up or become damaged.
18. Put the cover on the pool and be sure it is properly secured.

Note: Iron, copper, manganese or other metals are less soluble in cooler temperatures. Adding a sequestering agent when winterizing will help reduce mineral stains.

CHAPTER THIRTEEN

Legal and Liability

Chapter Objectives

1. To develop an appreciation for following proper procedures for pool operations.
2. To understand the importance of following all Health Department regulations.
3. To become familiar with the "Ten Commandments" of legal liability.
4. To develop an understanding of the importance of regular in-service training for all pool staff.

References:
Most of the information in this section is reprinted from YMCA Aquatic School
Robert J. Orozco
National YMCA
Aquatic Program Director

LEGAL AND LIABILITY

Common Reasons for Liability Suits

1. Failure to provide safe facilities
   The facility has slippery decks, inadequate lighting, steps, and handrails, which do not comply with codes.
2. Failure to provide safe equipment
   The facility has a diving board with flaws, ladder handrails with sharp edges, a dock with protruding nails.
3. Failure to provide safety equipment
   The area lacks ring buoys, lifeboats, restraining lines.
4. Failure to Supervise
   No lifeguard is on duty, an insufficient number of guards are provided, and an instructor or guard leaves the facility unattended.
5. Failure to post
   The management has permitted a lack of or an insufficiency of signs indicating water depths, beach boundaries, age limitations on certain equipment, parents' responsibility for small children, boating regulations, and warnings pertaining to hazardous facilities and equipment.
6. Failure to comply with laws
   The management has permitted conditions of impure water and unsanitary facilities to exist. It has permitted ineffective laundering and disinfecting of towels and suits.
7. Failure to provide security
   Doors, gates, or windows have been left unlocked. A fence around an outdoor facility is lacking.
8. Failure of an employee to properly perform his duties
   An employee may be judged as failing to properly perform his duties if he is guilty of such improper actions as talking to persons while he is on guard duty, leaving his post of duty, engaging in unapproved activities, etc.

9. Improper action

Doing more than necessary when giving assistance. Giving medication or treatment beyond approved first-aid practices or giving incorrect first-aid treatment. Mishandling an injured person. Permitting activities that are dangerous to others. Issuing equipment that is dangerous to the user.

10. Lack of action

An employee may be judged as failing to properly perform his duties if he is guilty of such actions as failure to:

1. Comply with employer's instructions
2. Apply first-aid treatment
3. Comply with parents' wishes
4. Advise an injured person to obtain follow-up treatment
5. Act promptly in effecting a rescue
6. Restrict swimmers from the diving area – failure to restrict boats from the swimming area
7. Enforce regulations and to eject violators
8. Inspect the facility and equipment regularly
9. Foresee the possibility of an accident
10. Exclude the introduction of dangerous objects
11. Failure to administer properly
12.

Negligence is a term that can sum up almost everything mentioned in this section. This one word is the single most common cause of lawsuits in the aquatic industry. Covering a broad area of topics, negligence is doing something wrong, not doing what should've been done, going beyond the level of training, etc.—not doing your job the exact way it should've been done. Negligence covers many things.

Staff should document all incidents and accidents on the facility's appropriate form. Staff should be encouraged to take down witness information at the time of the accident and have participants in the incident sign a statement of what happened.

Fill in the chart with the range of each reading and the chemical name that raises and lowers each reading:

Chemical	Minimum	Maximum	Raise	Lower
Chlorine				
pH				
Total Alkalinity				
Calcium Hardness				
Cyanuric Acid				
Total Dissolved Solids	No Minimum		Not Applicable	

Appendices

Appendix A

Recommendations for Bromine-based sanitation of pools and spas
This is an excerpt from a letter by Mary Costanzo, Research and Development, Bio-Lab Inc., March 10, 1993.
Bromine-based sanitation of indoor pools and spas has several advantages over chlorination of these facilities. It is necessary to be aware of several points in properly maintaining the best possible water quality.

1. Bromine pools and spas need to be shocked. This can be done with oxygen-based shocking compounds or with chlorine-based compounds. The frequency of shocking is determined by several factors, i.e., bather load, turnover time, filtration efficiency, type of population using the facility, and of course, the local Health Department regulations. A suggested minimum would be a weekly shock utilizing an oxygen-based shock, with a chlorine-based shock being utilized every fourth week in place of the oxygen-based shock. If the bather load exceeds 25 people per 10,000 gallons, the recommended frequency is an oxygen-based shock midweek and a chlorine-based shock every weekend.

   The recommended quantity of shock is 1 pound of oxygen-based shock per 10,000 gallons. Use 1 pound of Calcium Hypochlorite for every 10,000 gallons or 1 pound of Lithium hypochlorite per 6,000 gallons for the chlorine-based shock. DO NOT USE SODIUM DICHLOR to shock a brominated pool.

   Note: Although oxygen-based shocks are sufficient in many uses, the oxidation potential of oxygen is not as great as chlorine. The higher level of oxidation is needed on a scheduled, but less frequent basis.

2. A properly sized brominator is a must in obtaining the correct level of Bromine in the water. Bromine tablets are less soluble than chlorine tablets and require that more surface area be exposed to the water flow. The best situation would involve the use of an automatic controller, with a solenoid on the inlet of the brominator activated by the controller.
3. Bromine usage generally results in a loss in Total Alkalinity as the bicarbonate ion is used as a replacement on the carrier molecule of the bromine compound. In common situations, it will require about one pound of alkalinity increaser for each pound of bromine tablets used to balance the alkalinity changes.
4. When utilizing a test kit, if purplish color develops in the pH test vial, this is an indication of very high bromine residual. Do not adjust pH until the bromine residual is brought down and no longer interferes with pH testing.
5. When an oxygen-based shock is utilized, the bromide ions present in the water are converted to hypobromous acid, the active form of the bromine. This is the form, which registers on a test kit. Therefore, following a shock with an oxygen-based shock, the Total Available Bromine reading will increase.
6. It is extremely important to maintain proper residuals at all times. The recommended residuals are 3 to 8 PPM in a pool and 4 to 8 PPM in a spa. Check with the local Health Department for local protocols.

APPENDIX B

Use Proper Precautions with Chemicals
While many of the chemicals found in the back of the pool/spa technician's truck are basically the same ones found in the cupboards of almost every household, only stronger – bleach, dishwashing detergent, etc., these substances can be dangerous. Many products used by pool/spa technicians are highly incompatible. Handling or storage mishaps can lead to a reaction between chemicals that could endanger public health. Service technicians who use these chemicals daily must be especially well informed on the correct procedures to follow in the event of a minor spill. Most of this information can be found on Material Safety Data Sheets.

According to Princeton University: "In the event of a chemical spill, the individual(s) who caused the spill is responsible for prompt and proper clean-up. It is also their responsibility to have spill control and personal protective equipment appropriate for the chemicals being handled readily available." Refer immediately also to your facility's Spill Response Plan for more information.

"The following are general guidelines to be followed for a chemical spill. More detailed procedures may be available in your Departmental Chemical Hygiene Plan or Spill Response Plan.

1. Immediately alert area occupants and supervisor, and evacuate the area, if necessary.
2. If there is a fire or medical attention is needed, contact Public Safety at 911.
3. Attend to any people who may be contaminated. Contaminated clothing must be removed immediately, and the skin flushed with water for no less than fifteen minutes. Clothing must be laundered before reuse. See First Aid for Chemical Exposures for more information.
4. If a volatile, flammable material is spilled, immediately warn everyone, control sources of ignition, and ventilate the area.
5. Don personal protective equipment, as appropriate to the hazards. Refer to the MSDS or other references for info.
6. Consider the need for respiratory protection. The use of a respirator or self-contained breathing apparatus requires specialized training and medical surveillance. Never enter a contaminated atmosphere without protection or use a respirator without training. If respiratory protection is needed and no trained personnel are available, call 911. If respiratory protection is used, be sure there is another person outside the spill area in communication with 911.
7. Using the chart below, determine the extent and type of spill. If the spill is large, if there has been a release to the environment or if there is no one knowledgeable about spill clean-up available, contact Public Safety at 911.

Category	Size	Response	Treatment Materials
Small	up to 300cc	chemical treatment or absorption	neutralization or absorption spill kit
Medium	300 cc - 5 liters	absorption	absorption spill kit
Large	more than 5 liters	call public safety	outside help

8. Protect floor drains or other means for environmental release. Spill socks and absorbents may be placed around drains.
9. Contain and clean-up the spill, according to the table above. Loose spill control materials should be distributed over the entire spill area, working from the outside, circling to the inside. This reduces the chance of splash or spread of the spilled chemical. Bulk absorbents and many spill pillows do not work with hydrofluoric acid. POWERSORB (by 3M) products and their equivalent will handle hydrofluoric acid. Specialized hydrofluoric acid kits also are available. Many neutralizers for acids or bases have a color change indicator to show when neutralization is complete.
10. When spilled materials have been absorbed, use a brush and scoop to place materials in an appropriate container. Polyethylene bags may be used for small spills. Five-gallon pails or 20-gallon drums with polyethylene liners may be appropriate for larger quantities.
11. Complete a hazardous waste sticker, identifying the material as Spill Debris involving XYZ Chemical, and affix onto the container. Spill control materials will probably need to be disposed of as hazardous waste. Contact EHS for advice on storage and packaging for disposal.
12. Decontaminate the surface where the spill occurred using a mild detergent and water, when appropriate.
13. Report all spills to your supervisor or the Principal Investigator."

APPENDIX C

Record Keeping

The following is a sample operating record. This particular operating record is set-up according to the State of Maryland Health Department regulations. This does not mean that this is the operating record you must use.

Any facility can develop its own operating record(s) as long as all of the requirements are being recorded in the time(s) specified by the local Health Department. Pool Operators should always consult the local Health Department regulations BEFORE beginning to operate a pool in a new location.

Each individual Health Department may have different requirements. Students do have permission to reproduce this operating record for use at their facility.

SWIMMING POOL OPERATING RECORD

Sheet #: ________ POOL: ______________________ Month: ________ Year: ________

			TEST EVERY TWO (2) HOURS				RECORD THREE (3) TIMES PER DAY										RECORD AS REQUIRED (Minimum once per day)									
								TEMP		CLARITY	PRESSURE						WATER							OTHER CHEMICAL		
DATE	Time of test	Pool Operator	FAC ppm	TAC ppm	CAC ppm	pH	Number of users	Air	Water	CR=clear CL=cloudy	Influent Filter 1	Effluent Filter 1	Influent Filter 2	Effluent Filter 2	VACUUM GAUGE	RATE OF FLOW GPM	WATER LEVEL +NORM-	ADDED	DRAINED	TIME OF BACK-WASH	EQUIPMENT PROBLEM	Accident or Injury Report	Chemical Additions	AMOUNT	KIND	NOTES

Temp (F)	Temp Factor (TF)	Calcium Hardness (CH) ppm	Calcium Factor (CF)	Total Alkalinity (TA) ppm	Alkalinity Factor (AF)
32	0.0	5	0.3	5	0.7
37	0.1	25	1	25	1.4
46	0.2	50	1.3	50	1.7
53	0.3	75	1.5	75	1.9
60	0.4	100	1.6	100	2.0
66	0.5	150	1.8	150	2.2
76	0.6	200	1.9	200	2.3
84	0.7	300	2.1	300	2.5
94	0.8	400	2.2	400	2.6
105	0.9	800	2.5	800	2.9

SATURATION INDEX

RECORD AT LEAST ONCE PER WEEK

SI = pH + TA + CH + TEMP

SI = pH + AF + CF + TF - 12.1

DATE	PO	TIME	PH	AF	CF	TF	-	12.1	=	SATURATION INDEX
							-	12.1	=	
							-	12.1	=	
							-	12.1	=	
							-	12.1	=	
							-	12.1	=	
							-	12.1	=	

POOL OPERATORS

Initial	Name

SWIMMING POOL OPERATING RECORD

Sheet #: ____________ POOL: ________________________________ Month: ________ Year: ________

			TEST EVERY TWO (2) HOURS				RECORD THREE (3) TIMES PER DAY										RECORD AS REQUIRED (Minimum once per day)									
DATE	Time of test	Pool Operator					Number of users	TEMP		CLARITY	PRESSURE				VACUUM GAUGE	RATE OF FLOW GPM	WATER			TIME OF BACK-WASH	EQUIPMENT PROBLEM	Accident or Injury Report	Chemical Additions	OTHER CHEMICAL		NOTES
			FAC ppm	TAC ppm	CAC ppm	pH		Air	Water	CR=clear CL=cloudy	Influent Filter 1	Effluent Filter 1	Influent Filter 2	Effluent Filter 2			WATER LEVEL +NORM-	ADDED	DRAINED					AMOUNT	KIND	

Appendix C
Sample Data Sheet

SWIMMING POOL DATA SHEET		
	Main Pool	**Wading Pool**
Gallon Capacity	83,330 Gallons	1,687 Gallons
Surface Area	2,580 Square Feet	256 Square Feet
Flow Rate	173 GPM	14 GPM
Inlets	12 Floor Returns	3 Floor Returns
Sanitizer	Sodium Hypochlorite	Sodium Hypochlorite

OPERATING INSTRUCTIONS		
	Main Pool	**Wading Pool**
To Filter:	Open valves labeled skimmer, main drain, filter, and return. Close valves labeled vacuum, backwash, and waste.	Set multi-port valve to FILTER.
To Backwash:	Open valves labeled skimmer, main drain, backwash, and waste. Close valves labeled vacuum, filter, and return.	Set multi-port valve to BACKWASH, and after backwashing, set multi-port valve to rinse for about 20 seconds.
To Vacuum:	Open valves labeled skimmer, vacuum, and return. Close valves labeled main drain, backwash, and waste.	Set multi-port valve to FILTER. Vacuum through the skimmer. The other skimmers may need to be closed in order to get enough suction
Important Notes:	1. Always turn off pump before changing any valve settings 2. Never run chlorinator while system is off or backwashing	

Remember: If you have questions about how to operate your system, ask you supervisor. Do not turn the system on with valves in a position that you are not certain about. The water must be able to get out of the pool via the main drain, skimmer and/or vacuum line and it must have somwhere to go via the return or backwash line. **IF YOU DON'T KNOW.........ASK!!!!**

APPENDIX D

Sample of Safety Data Sheet: Calcium Hypochlorite

CLEARTECH

Safety Data Sheet

Section 01 - Identification

Product Identifier — Calcium Hypochlorite, Granular; Bio Sanitizer Pucks

Other Means of Identification — Calcium oxychloride; chlorinated lime; hypochlorous acid; Chlortabs; bleaching powder; calcium chlorohydrochlorite; lime chloride.

Product Use and Restrictions on Use — Disinfection in swimming pools and drinking water supplies; slime and odour control. Sanitizer and oxidizer.

Initial Supplier Identifier — ClearTech Industries Inc.
1500 Quebec Avenue
Saskatoon, SK. Canada
S7K 1V7

Prepared By — ClearTech Industries Inc. Technical Writer
Phone: 1 (800) 387-7503

24-Hour Emergency Phone — Phone: 1 (306) 664 – 2522

Section 02 - Hazard Identification

GHS-Classification

Acute Toxicity-Oral — Category 4

Skin Corrosion/Irritation — Category 1B

Serious Eye Damage/Irritation — Category 1

Physical Hazards

Oxidizing Solid — Category 2

Danger

Hazards Statements
H302 – Harmful if swallowed.
H314 – Causes severe skin burns and eye damage.
H272 – May intensify fire; oxidiser.

Pictograms

Page 1 of 8

Precautionary Statements
P405 – Store locked up.
P210 – Keep away from heat, sparks, open flames, and hot surfaces. — No smoking.
P220 – Keep/Store away from clothing, incompatible and combustible materials.
P280 – Wear protective gloves, protective clothing, eye protection, and face protection.
P370 + P378 – In case of fire: Use flooding quantities of water spray for extinction.
P260 – Do not breathe dust.
P304 + P340 – IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P270 – Do not eat, drink or smoke when using this product.
P301 +P330 + P331 – IF SWALLOWED: Rinse mouth. Do NOT induce vomiting.
P305 + P351 + P338 – IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P303 + P361 + P353 – IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin.
P363 – Wash contaminated clothing before reuse.
P310 – Immediately call a POISON CENTER or doctor/physician.
P501 – Dispose of contents/container in accordance with all federal, provincial, and/or local regulations including the Canadian Environmental Protection Act.

Section 03 - Composition / Information on Ingredients

Chemical Name	CAS Number	Weight %	Unique Identifiers
Calcium Hypochlorite	7778-54-3	60-80%	
Sodium Chloride	7647-14-5	10-20%	
Calcium Chlorate	10137-74-3	0-5%	
Calcium Chloride	10043-52-4	0-5%	
Calcium Hydroxide	1305-62-0	0-4%	
Calcium Carbonate	471-34-1	0-5%	
Water	7732-18-5	5.5-10%	

Section 04 - First Aid Measures

Inhalation — Remove victim to fresh air. Give oxygen only if breathing has stopped. If breathing is difficult, give oxygen. Seek immediate medical attention.

Skin Contact / Absorption — Remove contaminated clothing under running water. Rinse skin with lukewarm, gently flowing water for at least 30 minutes. If irritation persists, repeat flushing. DO NOT INTERRUPT FLUSHING. Seek immediate medical attention. Completely decontaminate clothing, shoes and leather goods before reuse or discard.

Eye Contact — Immediately flush the contaminated eye(s) with lukewarm, gently flowing water for at least 30 minutes. Neutral saline solution may be used as soon as it is available. Seek immediate medical attention.

Ingestion — NEVER give anything by mouth if vicitim is rapidly losing consciousness, is unconscious or convulsing. Have victim rish mouth thoroughly with water. DO NOT INDUCE VOMITING. Have vicitm drink 240 to 300mL of water to dilute material in stomach. If vomiting occurs naturally, repeat water administration. Seek immediate medical attention.

Additional Information — Can release corrosive chlorine gas. Take proper precautions to ensure your own safety before attempting rescue. DO NOT allow victim to move about unnecessarily. Symptoms of pulmonary edema can be delayed up to 48 hours after exposure. Avoid mouth-to-mouth contact by using mouth guards or shields.

Section 05 - Fire Fighting Measures

Suitable Extinguishing Media — Use extinguishing agents suitable for the surrounding fire and not contraindicated for use with calcium hypochlorite. Calcium hypochlorite is an oxidizing agent. Therefore, flooding quantities of water spray or fog should be used to fight fires involving calcium hypochlorite.

Page 2 of 8

Unsuitable Extinguishing Media — DO NOT use dry chemical fire extinguishing agents containing ammonium compounds (such as some A:B:C agents), since an explosive compound can be formed. DO NOT use carbon dioxide, dry chemical powder or other extinguishing agents that smother flames.

Specific Hazards Arising From the Chemical — Calcium hypochlorite can undergo accelerated decomposition with the release of significant amounts of heat, chlorine and oxygen, forming an oxygen-rich atmosphere. Calcium hypochlorite is a serious fire and explosion hazard when contaminated with, or comes in contact, with oxidizable, combustible materials. Combustion and thermal decomposition products include: chlorine, hydrogen chloride gas, oxygen gas and calcium oxides.

Special Protective Equipment and Precautions for Fire-Fighters — Wear NIOSH-approved self-contained breathing apparatus and protective gear.

Further Information — Decomposition products are extremely hazardous to health.

Section 06 - Accidental Release Measures

Personal Precautions / Protective Equipment / Emergency Procedures — Wear appropriate personal protective equipment. Ventilate area. Only enter area with PPE. Stop or reduce leak if safe to do so. Flush with water to remove any residue.

Environmental Precautions — Prevent material from entering sewers, waterways or confined spaces. Chlorine is highly toxic to all forms of aquatic life.

Methods and Materials for Containment and Cleaning Up — SMALL SPILLS: Collect, using a clean, dry shovel. Transfer to a container, that contains water. Carefully destroy the hypochlorite by adding hydrogen peroxide. Hydrogen peroxide reacts with calcium hypchlorite to form calcium chloride and oxygen gas. Do not close container. Other chemicals that can be used are sodium sulfite and sodium bisulfite. Once calcium hypochlorite is reduced, the remaining solution should be neutralized cautiously with dilute hydrochloric or sulfuric acid.
LARGE SPILLS: Contact fire and emergency services and the supplier for advice.
NOTE: Oxygen may be released during neutralization. Decontamination should be done in an open container, in a well-ventilated area away from sources of ignition.

Section 07 - Handling and Storage

Precautions for Safe Handling — This material is a MODERATE to STRONG OXIDIZER and is CORROSIVE. Use proper equipment for lifting and transporting all containers. Use sensible industrial hygiene and housekeeping practices. Wash thoroughly after handling. Avoid all situations that could lead to harmful exposure.

Conditions for Safe Storage — Keep product tightly sealed in original containers. Store product in a cool, dry, well-ventilated area. Store away from combustible or flammable products. Do not store product where the average daily temperature exceeds 35°C/95°F. Storage above this temperature may result in rapid decomposition, evolution of chlorine gas and heat sufficient to ignite combustible products.

Incompatibilities — Flammable and combustible materials, ammonia, primary amines, urea, acids, ammonium chloride, ethanol or methanol, hydroxyl compounds, acetylene, acetic acid and potassium cyanide, reducing agents, metal oxides, charcoal, metals, organic sulfur compounds, sulfur, turpentine.

Section 08 - Exposure Controls and Personal Protection

Exposure Limit(s)

Component	Regulation	Type of Listing	Value
Calcium hypochlorite	Not Established		
Chlorine	ACGIH	TLV-TWA	0.5ppm
	ACGIH	TLV-STEL	1ppm
Calcium hydroxide	ACGIH	TLV-TWA	5mg/m³
	OSHA	PEL-T-TWA	15mg/m³
Calcium carbonate	OSHA	PEL-TWA	15mg/m³

Page 3 of 8

Engineering Control(s)

Ventilation Requirements — Mechanical ventilation (dilution or local exhaust), process or personnel enclosure and control of process conditions must be provided in accordance with all fire codes and regulatory requirements. Supply sufficient replacement air to make up for air removed by exhaust systems.

Other — Emergency shower and eyewash must be available and tested in accordance with regulations and be in close proximity.

Protective Equipment

Eyes/Face — Chemical goggles, full-face shield, or a full-face respirator should be worn at all times when product is handled. Contact lenses should not be worn; they may contribute to severe eye injury.

Hand Protection — Impervious gloves of chemically resistant material (rubber or PVC) should be worn at all times. Wash contaminated clothing and dry thoroughly before reuse.

Skin and Body Protection — Body suite, aprons, and/or coveralls of chemical resistant material should be worn at all times. Wash contaminated clothing and dry thoroughly before reuse.

Impervious boots of chemically resistant material should be worn at all times. No special footwear is required other than what is mandated at place of work.

Respiratory Protection — For chlorine:
Wear NIOSH-approved self-contained breathing apparatus and protective clothing.

NIOSH RECOMMENDATIONS FOR CHLORINE CONCENTRATIONS IN AIR:
Up to 5 ppm:
(APF = 10) Chemical cartridge respirator; SAR.
Up to 10 ppm:
(APF = 25) SAR operated in a continuous-flow mode; Powered, air-purifying respirator with cartridge(s).
(APF = 50) Chemical cartridge respirator with a full facepiece and cartridge(s); Air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister; SCBA with a full facepiece; Full facepiece SAR.

Emergency or planned entry into unknown concentrations or IDLH conditions:
(APF = 10,000) SCBA that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; SAR that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary SCBA

Escape:
(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister;
Any appropriate escape-type SCBA.

NOTE: The IDLH concentration for chlorine is 10 ppm.

Thermal Hazards — Not Available

Page 4 of 8

Section 09 - Physical and Chemical Properties

Appearance

Physical State	Solid
Colour	White
Odour	Slight chlorine odour
Odour Threshold	Not Available

Property

pH	10.4-10.8
Melting Point/Freezing Point	100°C
Initial Boiling Point and Boiling Range	Product decomposes @ 100°C
Flash Point	Not combustible
Evaporation Rate	Not Available
Flammability	Not flammable. Calcium hypochlorite is a strong oxidizing agent and can increase the risk of fire or the intensity of a fire.
Upper Flammable Limit	Not Applicable
Lower Flammable Limit	Not Applicable
Vapour Pressure (mm Hg, 20°C)	Does not form vapour.
Vapour Density (Air=1)	Not Applicable.
Relative Density	67-71kg/m³
Solubility(ies)	217g/L @ 27°C in water
Partition Coefficient: n-octanol/water	Log K_{ow} = -2.46
Auto-ignition Temperature	Not Applicable
Decomposition Temperature	170-180°C
Viscosity	Not Applicable
Explosive Properties	Not sensitive to mechanical impact or static discharge.
Specific Gravity (Water=1)	2.35
% Volatiles by Volume	Not Available
Formula	$Ca(ClO)_2$
Molecular Weight	142.98

Page 5 of 8

Section 10 - Stability and Reactivity

Reactivity	The National Fire Protection Association (NFPA) lists calcium hypochlorite (over 50% by weight) as a class 3 oxidizer. Class 3 Oxidizers cause a sever increase in the burning rate of combustible materials with which they came into contact.
Stability	Inherently unstable. The rate of decomposition of the pure, dry material is extremely low at room temperature. Decomposition is accelerated in the presence of small amounts of water, moist air, carbon dioxide and/or the presence of contaminants.
Possibility of Hazardous Reactions	Small quantities will not usually undergo self-heating or spontaneous ignition under normal conditions of storage and handling. However, small quantities may spontaneuously ignite, either through self-heating due to decomposition or due to the presence of contaminants.
Conditions to Avoid	Heat, sunlight (a heat source), contamination with combustible materials, moisture/high humidity, acidic conditions, the presence of metals and other impurities.
Incompatible Materials	Flammable and combustible materials, ammonia, primary amines, urea, acids, ammonium chloride, ethanol or methanol, hydroxyl compounds, acetylene, acetic acid and potassium cyanide, reducing agents, metal oxides, charcoal, metals, organic sulfur compounds, sulfur, turpentine.
Hazardous Decomposition Products	Chlorine, oxygen, dichlorine monoxide, calcium chlorate, calcium hydroxide, calcium carbonate.

Section 11 - Toxicological Information

Acute Toxicity Estimate

Component	Oral LD_{50}	Dermal LD_{50}	Inhalation LC_{50}
Calcium Hypochlorite, HTH Tablets	951 mg/kg	2210 mg/kg	482 mg/m³

This product has been classified in accordance with the Hazardous Products Regulations using ATE formula documented in the GHS standard.

Chronic Toxicity – Carcinogenicity

Component	IARC
Calcium hypochlorite	Group 3: Not classifiable to its carcinogenicity to humans.

Skin Corrosion/Irritation	Corrosive to the skin.
Ingestion	Ingestion can cause burning of the mouth and throat. Product can be fatal if swallowed.
Inhalation	Inhalation of dust and deposition of particales in the respiratory tract can lead to irritation of the tissue and cause a variety of effects.
Serious Eye Damage/Irritation	Corrosive to the eyes.
Respiratory or Skin Sensitization	Not known to be a skin or respiratory sensitizer.
Germ Cell Mutagenicity	There is no human or animal information available. Calcium hypochlorite was mutagenic in bacteria and cultured mammalian cells.
Reproductive Toxicity	Not known to be toxic to reproduction.
STOT-Single Exposure	Severely irritating to respiratory system.
STOT-Repeated Exposure	Calcium hypochlorite can irritate the lungs.
Aspiration Hazard	Not Available.
Synergistic Materials	Not Available.

Page 6 of 8

Section 10 - Stability and Reactivity

Reactivity	The National Fire Protection Association (NFPA) lists calcium hypochlorite (over 50% by weight) as a class 3 oxidizer. Class 3 Oxidizers cause a sever increase in the burning rate of combustible materials with which they came into contact.
Stability	Inherently unstable. The rate of decomposition of the pure, dry material is extremely low at room temperature. Decomposition is accelerated in the presence of small amounts of water, moist air, carbon dioxide and/or the presence of contaminants.
Possibility of Hazardous Reactions	Small quantities will not usually undergo self-heating or spontaneous ignition under normal conditions of storage and handling. However, small quantities may spontaneuously ignite, either through self-heating due to decomposition or due to the presence of contaminants.
Conditions to Avoid	Heat, sunlight (a heat source), contamination with combustible materials, moisture/high humidity, acidic conditions, the presence of metals and other impurities.
Incompatible Materials	Flammable and combustible materials, ammonia, primary amines, urea, acids, ammonium chloride, ethanol or methanol, hydroxyl compounds, acetylene, acetic acid and potassium cyanide, reducing agents, metal oxides, charcoal, metals, organic sulfur compounds, sulfur, turpentine.
Hazardous Decomposition Products	Chlorine, oxygen, dichlorine monoxide, calcium chlorate, calcium hydroxide, calcium carbonate.

Section 11 - Toxicological Information

Acute Toxicity Estimate

Component	Oral LD_{50}	Dermal LD_{50}	Inhalation LC_{50}
Calcium Hypochlorite, HTH Tablets	951 mg/kg	2210 mg/kg	482 mg/m³

This product has been classified in accordance with the Hazardous Products Regulations using ATE formula documented in the GHS standard.

Chronic Toxicity – Carcinogenicity

Component	IARC
Calcium hypochlorite	Group 3: Not classifiable to its carcinogenicity to humans.

Skin Corrosion/Irritation	Corrosive to the skin.
Ingestion	Ingestion can cause burning of the mouth and throat. Product can be fatal if swallowed.
Inhalation	Inhalation of dust and deposition of particales in the respiratory tract can lead to irritation of the tissue and cause a variety of effects.
Serious Eye Damage/Irritation	Corrosive to the eyes.
Respiratory or Skin Sensitization	Not known to be a skin or respiratory sensitizer.
Germ Cell Mutagenicity	There is no human or animal information available. Calcium hypochlorite was mutagenic in bacteria and cultured mammalian cells.
Reproductive Toxicity	Not known to be toxic to reproduction.
STOT-Single Exposure	Severely irritating to respiratory system.
STOT-Repeated Exposure	Calcium hypochlorite can irritate the lungs.
Aspiration Hazard	Not Available.
Synergistic Materials	Not Available.

Page 6 of 8

Section 15 – Regulatory Information

NOTE: THE PRODUCT LISTED ON THIS SDS HAS BEEN CLASSIFIED IN ACCORDANCE WITH THE HAZARD CRITERIA OF THE CANADIAN CONTROLLED PRODUCTS REGULATIONS. THIS SDS CONTAINS ALL INFORMATION REQUIRED BY THOSE REGULATIONS.

Section 16 – Other Information

Preparation Date	March 1, 2016
Revision Date	2018 January 29

Note: The responsibility to provide a safe workplace remains with the user. The user should consider the health hazards and safety information contained herein as a guide and should take those precautions required in an individual operation to instruct employees and develop work practice procedures for a safe work environment. The information contained herein is, to the best of our knowledge and belief, accurate. However, since the conditions of handling and use are beyond our control, we make no guarantee of results, and assume no liability for damages incurred by the use of this material. It is the responsibility of the user to comply with all applicable laws and regulations.

Attention: Receiver of the chemical goods / SDS coordinator

As part of our commitment to the Canadian Association of Chemical Distributors (CACD) Responsible Distribution® initiative, ClearTech Industries Inc. and its associated companies require, as a condition of sale, that you forward the attached Safety Data Sheet(s) to all affected employees, customers, and end-users. ClearTech will send any available supplementary handling, health, and safety information to you at your request.

If you have any questions or concerns please call our customer service center.

References:

1) CHEMINFO
2) eChemPortal
3) TOXNET
4) Transportation of Dangerous Goods Canada
5) HSDB
6) ECHA
7) PAN

ClearTech Industries Inc. - Locations

Corporate Head Office: 1500 Quebec Avenue, Saskatoon, SK, S7K 1V7

Phone: 1(306) 664 – 2522

Fax: 1(888) 281-8109

www.cleartech.ca

24 Hour Emergency Number - All Locations – 1(306) 664-2522

Page 8 of 8

APPENDIX E

GLOSSARY

Automatic Feeders: Electronically controlled pool equipment that monitors and adjusts pool chemicals, particularly pH and chlorine levels.

Backwash: The process of reversing or redirecting the water flow through a sand filter, for the purpose of cleaning the filter. Particulate matter accumulates in the filter bed and, over time, can reduce the efficiency of the filter thus reducing water flow. Backwashing removes this particulate matter and sends it to waste.

Backwash Cycle: The time required to backwash the filter media and elements completely.

Bacteria: One-celled organisms that can either be pathogenic (disease-producing) or non-pathogenic. A bactericide is a chemical that kills bacteria.

Baquacil: A nonchlorine polymer uses as a swimming pool sanitizer and algistat. It cannot be used in conjunction with Chlorine.

Barrier: A fence, safety cover, wall, or a combination thereof that completely surround or covers the swimming pool and obstructs access to the swimming pool.

Bather Load: The number of swimmers in a pool at a given time. Many state codes determine maximum bather loads that should not be exceeded.

Balanced Water: Water that is neutral, that is neither corrosive nor basic. Balanced water possesses the correct combination of mineral and pH level.

Bleach out: Bleaching out can happen if a chlorine or bromine reading is extremely high (above 10 ppm). The reading appears to be turning pink but suddenly goes clear.

Breakpoint: The process of adding sufficient free available chlorine or other nonchlorine oxidants to convert chloramines and ammonia-nitrogen compounds to inert nitrogen gas. Breakpoint is achieved by most operators by superchlorination.

Broadcast: A method of introducing granular or powdered chemicals to a pool by spreading them widely over the surface.

Brominator: A device used to deliver bromine disinfectant to a swimming pool or spa at a controlled rate.

Bromine: Another acceptable disinfectant used in swimming pools/spas. Also, a member of the halogen family it offers some excellent disinfectant properties.

Buffer: A combination of weak acids and weak bases and their salts that help to resist changes in pH. Sodium bicarbonate is an example of a popular buffer used un pool water.

Calcification: The formation of hard cement-like sand within the sand filters. A build-up of calcium compounds can cause the sand to become cemented together. This can be caused when the water is flowing at too fast of a rate through the filters. Old sand can also become calcified.

Calcium Chloride: A soluble white salt used to raise the calcium hardness of the pool or spa water.

Calcium Hardness: Hardness is a measure of the mineral content of water. It is associated with several compounds, including calcium and magnesium carbonates, sulfates, chlorides, and nitrates, iron, and manganese compounds.

Calcium Hypochlorite: A dry inorganic chlorine that is available in granular form or tablets. It contains 65% active available chlorine. Calcium hypochlorite is flammable and must be handled with care.

Cartridge Filters: Cylindrical shaped filter elements with a cloth-like fabric "accordion-folded" around the cylinder. Cartridge Filters remove contaminants by a straining process through the fabric material of the cartridge.

Channeling: The formation of channels or hollow tunnels in the sand bed due to excessive mudballs and/or calcification. The water continues to flow through the filter by way of these hollow channels, but it is not being filtered.

Chelating Agents: Chemical compounds used to keep metals and minerals in solution, so that they do not precipitate out in the pool water.

Chemical Feeder: A mechanical device used to dispense pool chemicals in the pool water.

Chloramines: Chlorine/ammonia compounds. They are more stable than free chlorine, but not as effective. Chloramines can cause eye irritation and an irritating odor, especially noticed in indoor pools.

Chlorinator: A chemical feeder used specifically for dispensing chlorine into pools.

Chlorine: The most common disinfectant used in the pool industry. Chlorine is a member of the Halogen family and serves as both a disinfectant and oxidizer for swimming pool water.

Chlorine Demand: The amount of chlorine needed to disinfect and oxidize all undesirable matter in the pool, including ammonia and nitrogenous wastes plus chloramines, bacteria and oxidation of water contaminants.

Chlorine Generator: Equipment that generates chlorine, hypochlorous acid or hypochlorite on-site for disinfection and oxidation of water contaminants. These systems usually are salt systems.

Chlorine Residual: The FAC or Free Available Chlorine level. The term residual is sometimes used in place of the term "reading" or "level."

Clarity: Refers to how clear or transparent water is. Water clarity is determined by how easily objects can be detected underwater at depth. Water clarity should not be confused with water quality, which refers to bacteria and other contaminants.

Clarifier: May also be referred to as a coagulant or flocculant. A chemical that coagulates and neutralizes suspended particles in water. There are two basic types: inorganic salts of aluminum or iron and water-soluble organic polyelectrolyte polymers.

CNCA: The Council for National Cooperation of Aquatics. A national organization of numerous agencies sharing an interest in improving aquatic safety and education. This organization promotes all phases of aquatics.

Colorimetric: A chemical testing procedures by which various shades and hues of colors are compared to determine chemical levels present in pool water. Most chlorine and pH test are colorimetric tests.

Coliform: A type of bacteria found in the intestines of warm-blooded animals. When coliform is found in pool water, disease-producingg bacteria may also be present. E and B Coli coliform tests are performed by health officers or certified labs and are generally accepted as a standard of water contamination.

Combined Available Chlorine (CAC): Free available chlorine combined with ammonia and nitrogen compounds. This formation is called a chloramine.

Comparator: The device used to collect pool water so that it can be tested. It is usually made of clear acrylic and offers a color chart that allows the operator to compare levels and readings after the reagents have been added.

Coping: The cap of the pool or spa wall that provides a finishing edge around the pool or spa. It may also be used to secure a vinyl liner to the top of the pool wall.

Copper: A metal found in some water supplies and used in many plumbing fixtures. Blue/green water may indicate that high levels of copper exist in the water supply or corrosive water is corroding pool pipes or heater elements.

Corrosion: To consume away gradually by chemical action. Caused by aggressive, acidic or soft water. This deterioration can be easily prevented by keeping the pH above 7.2 and by maintaining balanced water according to the Saturation Index.

Corrosive Water: Water that is imbalanced by a deficiency of certain minerals or components and seeks to satisfy its hunger by dissolving virtually everything it contacts.

CPO – Certified Pool Operator: Someone with swimming pool/spa operations knowledge, including but not limited to the following: water disinfection and chemistry, along with circulation, filtration, and many other miscellaneous topics.

Crevicing: A vacancy on one side of the filter tank that forms when the sand bed shifts to one side of the tank. Water can pass through the empty crevice without being properly filtered. A slip in the position of the diffuser can cause this to happen.

Cyanuric Acid: The chemical used to stabilize the disinfectant level in an outdoor pool and extends that life of chlorine in outdoor pools. Cyanuric Acid protects chlorine from the dissipating effects of sunlight. Cyanuric Acid can be added directly to the pool or it can be purchased already combined with chlorine in tablets, pucks or sticks.

Diatomaceous Earth (DE): A fine white powder used as a filter media. D.E. is capable of outstanding filtration, screening out particles as small as one micron in size. DE is composed of fossilized marine life skeletons called diatoms. Because these diatoms are porous, excellent water clarity results when DE filters are used.

Dead spots: Areas of poor circulation within the pool basin, where there is little water movement. As a result, the disinfectant may not get to those areas, and bacteria and algae can grow undeterred.

Diffuser: A device at the top of the filter tank that distributes the water evenly onto the filter bed.

Disinfectant (Sanitizer): The chemical or device that kills or inactivates the microorganisms present in pool/spa water.

Disinfection - (Sanitize): The process of destroying living microorganisms and bacteria in sufficient numbers (by definition – 99.9%) to prevent the transmission of disease.

DPD: (N,N-Dimethyl-P-Phenylone-Diamine), liquid or tablet form, is the most common disinfectant testing reagent.

Dry Acid (Sodium Bisulfate): This granular chemical is safer and easier to use than muriatic acid for lowering both pH and Total Alkalinity.

Dry-Niche Lights: Lights which are located outside of the shell of the pool. In some instances, these lights will shine through a glass window into the pool. These are more commonly found in older indoor pools.

Effluent: Exiting or outflowing water from a pool, pump, or filter.

Electrode: A sensor used in automatic pool controllers that aids in reading and controlling chemical levels. Electrodes are usually placed inside the pool circulation lines. Silver and copper electrodes may also be used to ionize the water for disinfection and algae control.

Emergency Action Plan (EAP): An EAP is a step-by-step plan to handle an emergency.

Equalizer: A line that is sometimes added between the bottom of the skimmers and the pool wall to prevent aid from being sucked into the filter when the water level is below the skimmer box inlet. When the water level does drop, the equalizer automatically draws water from the pool into the skimmer and back to the filter.

Erosion feeder: An enclosed apparatus used in dispensing disinfectants. Water flows through the feeder, eroding away the solids inside and sends the disinfected water to continue through the system.

Feet of Head: A measurement of pressure or resistance in a hydraulic system. Feet of head is equivalent to the height of a column of water that would create the same amount of resistance. (100 feet of head equals 43 pounds per square inch)

Filter Aid: Any chemical or other substance that is added to the water to increase the filters efficiency.

Filter Run (Filter Cycle): The time between backwashes. This time varies from pool to pool and can be affected by weather, bather load, and other factors.

Filter Septum: The individual filter membranes found in a DE and some other filtration systems. Can be made of fabric, wire, or similar material. DE clings to the septa in order to trap particles suspended.

Filtration: The removal of particulate matter from water by forcing the water through a filter media (sand, diatomaceous earth, filter cartridges, etc.).

Flocculent: A chemical compound added to some sand filters that aids filtration by creating foaming, gelatinous mass (called the floc) on top of the filter bed, which traps finer particles that might normally pass through the sand.

Flow Meter: A device used to determine the rate in GPMs (Gallons per Minute) that the water is flowing through the filtration system. A flowmeter is necessary to determine the effectiveness of the recirculation system. They come in varying types and sizes.

Flow Rate: The rate at which the water moves through the filtration system. There are minimum rate requirements to ensure that the water is moving at a sufficient rate in order to "turn over" the entire pool volume within a specified period of time.

Free Available Chlorine: Uncombined usable chlorine that is free to kill bacteria and algae and oxidize organic material. This is the most active and desirable form of chlorine. Free available chlorine is composed of hypochlorous acid (HOCL) and hypochlorite ion (OCL).

Freeboard: The clear vertical distance between the top of the filter medium and the lowest outlet of the upper distribution system in a permanent medium filter.

Galvanic Corrosion: the corrosion of metals that takes place when two or more different metals are submerged in an electrolyte.

Grab Rail: Tubular rails used to enter or exit a pool or spa usually made of stainless steel or chrome-plated brass.

Gunite: A dry mixture of cement and sand sprayed onto contoured and supported surfaces to build a pool or spa. Water is added to the dry mixture at the nozzle.

Gutter: An overflow trough that runs around the entire perimeter of the pool over which water flows constantly. The water is then drawn from the gutters into the pump system.

Hair and Lint Pot (Hair strainer): A component of the pump system located **before** the pump to catch debris. It filters the incoming water, trapping large particles in a basket. The basket must be cleaned frequently to ensure the pump is protected and the water flow is not inhibited.

Halogen: Any element found in the Group VII of the periodic table. Due to their tremendous chemical reactivity, the halogens never occur free in nature; they must be prepared from their stable salt (i.e. sodium chloride [NaCl]. Chlorine, bromine, and iodine are examples of halogens.

Hardness (hard water): Water that contains high levels of calcium and magnesium compounds and other minerals. Hard water produces scale, which in turn clogs pipes filters and heaters.

Hydrostatic relief valve: A valve located at the lowest point in the pool basin that, when opened, will allow groundwater to escape into the pool basin to relieve the pressure beneath the pool structure. This valve prevents an empty pool from *floating* and sustaining significant damage.

Hypobromous Acid: The primary chemical species responsible for disinfection in bromine treated pools and spas.

Hydrochloric Acid (Muriatic Acid): An extremely strong acid used to lower pH as well as a cleaning agent for diving boards, decks, etc. Also produced when chlorine gas is added with water.

Hydrogen: The lightest chemical element that is a component of water and a product of many chemical reactions. It can be used to measure acidity and pH.

Hydrogen Ions: The positively charged nucleus of a hydrogen atom and can be used to measure the acidity of a solution.

Hypochlorite: A pool chemical containing chlorine used for disinfection and oxidation**.** Often refers to calcium, sodium or lithium hypochlorite.

Hypochlorous Acid: The primary chemical species responsible for the disinfection of pools and spas. HOCl is very active. It destroys harmful organisms such as bacteria, algae, and fungi.

Impeller: A rotor located within the pump that draws the water through the system by turning.

Influent: Water flowing into a pump, filter, pool, or other vessels.

Inorganic: Compounds that do not contain carbon and are VERY sensitive to UV light.

Iodide: A chemical compound containing iodine that will be released when placed in pool water. Potassium and sodium iodide are both used for pool disinfection.

Iodine: A halogen that can be used for swimming pool disinfection but is not common. Although it si an excellent bactericide, iodine is not an effective algaecide.

Ionization: An electrochemical process using electrodes to convert neutral or non-charged atoms, molecules, or compounds to electrically charged ions. Ionization is used as an alternative sanitizer in some pools to reduce their dependence on chemicals. Staining may accompany ionization.

Iron: When found in high concentration in water supplies may precipitate out in red, brown, or murky colors and stain the bottom of the pool.

Lifeline: A line running across the surface of the pool dividing shallow and deep ends and prevents non-swimmers from sliding down the slope into the deep water. Floats are normally attached.

Laterals: Underdrains located in the bottom of the filter tank that have very fine slots in them that allow the water to pass through but not sand.

Lithium Hypochlorite: A dry granular chlorine that is extremely soluble. This chlorine type is often used as a shocking agent but is quite expensive.

Material Safety Data Sheets: Informational sheets on chemicals.

Make-up Water: Outside fresh water used to fill or add water to swimming pools.

Microorganisms: Microscopic plants or animals that cannot be eliminated from pool water. If disease-causing, it is called a "pathogen."

Mudballs: Sand particles held together by organic matter (hair, lint, body oil, body grease, suntan lotion, etc.) that form within the filter tanks. If allowed to continue accumulating, mudballs can produce weak spots in the filter bed and cause channeling. Sodium Hydroxide will dissolve mudballs and allow the dirt and other particles to be backwashed away.

Muriatic Acid: Also known as hydrochloric acid or hydrogen chloride, this strong acid is used primarily to reduce pH and total alkalinity. Muriatic acid is extremely corrosive and must be stored and handled with care. Toxic gas is produced when sodium hypochlorite and muriatic acid comes in contact with each other.

Negligence: A term that covers a broad area of topics including (but not limited to) doing something *wrong,* not doing what should have been done, going beyond the scope of training, etc. It is the single most common cause of lawsuits in the aquatic industry.

Neutral: 7.0 on the pH scale is a neutral reading and is the pH of distilled water.

Nitrogen: An odorless, colorless, tasteless gas found combined in all living tissues. Nitrogen enters the pool combined with body oil, perspiration, and cosmetics and combines with free chlorine to produce chloramines. Chloramines result in odors and eye irritation. Nitrogen compounds also promote algae growth.

NSF: National Sanitation Foundation

NSPI: National Spa and Pool Institute. The major trade organization in the swimming pool industry.

NSPF: National Swimming Pool Foundation is an educational foundation promoting swimming pool research, education, and safety.

Organic: Compounds that contain carbon usually in combination with elements such as: hydrogen, oxygen, nitrogen, and sulfur and are NOT sensitive to UV light.

Organism: Animal or plant life like algae or bacteria that can grow in pool water.

ORP: The oxidation-reduction potential produced by strong oxidizing agents in a water solution. ORP or REDOX is a measure of the oxidation level measured in millivolts by an ORP Meter.

OTO: (Orthotolidine) test measures the total available chlorine only. It shows chlorine levels in yellow.

Oxidizers: Chemicals, like chlorine and bromine that rid the pool water of contaminants and microorganisms. Their chemical action literally burns away the undesirable content sending the gases into the atmosphere. Contact with heat, moisture, or foreign materials may result in fire.

Oxidation: The process of changing a compound or molecule from a lower to a higher positive oxidation state.

Ozone: An artificially on-site produced gas in the swimming pool industry used to disinfect and oxidize the pool water. Ozone is a bluish, pungent gas that is a triatomic form of oxygen ($O3$). Because of its poor residual properties, ozone is usually used as a supplemental oxidizer.

Pathogen: A microorganism causing disease

pH: The scale that identifies how acidic or how basic a solution is. It is a function of the hydrogen ion and hydroxide ion concentration and is defined as the negative log of the hydrogen ion concentration in a solution.

Phenol Red: The most common pH-testing reagent. It can be in the form of a liquid or a tablet. It is an acid/base indicator that changes color between pH 6.4 and 8.0.

Polymer: An agent used to clump, collect or flocculate suspended particles in water. Used as a filter aid.

Polyquat: A non-foaming algaecide.

Pool: A vessel constructed for the purpose of swimming.

Potable: Safe drinking water that is free of bacteria

Potassium Peroxymonosulfate: One type of nonchlorine shocking agent used to oxidize chloramines and organic waste.

Precipitate: An insoluble compound produced by a chemical reaction between compounds that are usually soluble. The process in which soluble invisible compounds in water become insoluble; visible is called precipitation. Calcium carbonates and iron are two common pool precipitates.

PPM: Parts per million. A measurement used in swimming pool testing that indicated the amount of chemical by weight in relation 1,000,000 part of water. For example, there are a million pounds of water in a 120,000-gallon pool. Therefore, a pound of gas chlorine in a 120,000-gallon pool equals one part per million.

Pseudomonas: A bacterium that thrives in warm water. It is a problem sometimes found in pools, but more often found in spas.

PSI: Pounds per square. It is used to describe the pressure in filter tanks or indicate head pressure.

Pump: A mechanical device usually powered by an electric motor that causes hydraulic flow and pressure for the purpose of filtration, heating, and circulation of pool and spa water.

Pump Cavitation: A violent shaking of the pump that happens when there is not a smooth flow of water through the pump, and the system is drawing air. The impeller relies on water flow to sustain its rhythm. When a pump cavitates too long, the impeller will be damaged or destroyed and eventually, the motor itself will be damaged or destroyed from the heat and vibration

Pump Curve: A graph showing the performance capabilities of a pump. It is measured in Feet of Head. Pumps that are too small will not produce the proper turnover rate. Pumps that are too large will force water through the filter so quickly that it will not filter properly.

Quat: A foaming algaecide.

Rate of Flow: The amount of water passing through a circulation system measure at a given point on the system; usually measured in gallons per minute (GPM) on a flow meter. Flow rate is essential to producing good water quality and clarity.

Reagents: The liquids, tablets, or powder used for to test the water for presence or absence of certain components in order to evaluate the overall health of the water.

Recirculation System: The closed-loop system used in a swimming pool to filter, heat, and chemically treat the water. It is composed of numerous parts, including pipes, pumps, and filters.

Residual: The amount of disinfectant or other chemical remaining in the swimming pool water. Although chlorine and bromine have good residual properties some other disinfectants do not.

Return Inlet: The aperture or fitting through which through treated water under positive pressure returns to a pool or spa.

RID Factor: Three factors adversely affecting the performance of lifeguards. Failure to Recognize victims, Intrusion of unnecessary, non-lifeguarding tasks, and Distraction from the task of protecting swimmers. It was developed by Frank Pia.

Ring Buoy: A common lifesaving device that is circular and buoyant. Normally has a long line attached and is meant to be thrown to a distressed swimmer.

Sand Filter: A swimming pool filter using specially graded sand or sand and gravel as the filter media to trap dirt and filter the water.

Sanitize: The process of destroying living microorganisms and bacteria in sufficient numbers (by definition – 99.9%) to prevent the transmission of disease.

Saturation Index: A scale developed to determine the degree of saturation by calcium carbonate ($CaC0_3$) in the water. It is an extremely important tool used to check water balance. If measured regularly, it can help to prevent corrosion and scale. The saturation index is a simple mathematical formula that measures the interrelation of temperature, calcium hardness, total alkalinity and pH to determine if the water is acidic, neutral or basic.

Scale (Scaling Water): Water that is imbalanced by an overabundance of components, provided either by nature or human mismanagement. Scaling water seeks to relieve its overfed condition by releasing precipitates either as scale, cloudiness or residue.

Sequestering Agent: A chemical that readily attaches itself to the metallic components in water and “coats” the metals rendering them incapable of attaching to, or depositing onto, any surface, thereby increasing the water’s ability to hold metals in solution.

Shelf Life: The length of time a material like a pool chemical) can be stored and remain suitable for its intended use.

Shocking: Producing high levels of chlorine on nonchlorine oxidizer to rid a pool of all chloramines and other organic wastes. Often refers to superchlorination or breakpoint.

Skimmers: Inlets located at certain intervals around the perimeter of the pool that draw the surface water into the pump system.

Skimmer Weir: see "weir."

Slip Resistant: A surface that has been treated or constructed is such a way as to significantly reduce the chance or the user slipping. The slip-resistant material must not cause an abrasion hazard.

Slurry Feed: A liquid (water and DE mix) administer in a DE filtration system that is added while the pump is on and extends the filter run.

Soda Ash (Sodium Carbonate): A white powder used to raise pH and total alkalinity in most swimming pools.

Sodium Bicarbonate (Baking Soda): A strong basic chemical used to raise pH and Total Alkalinity in pools.

Sodium Hydroxide: A common detergent used for periodically cleaning the sand filters.

Sodium Hypochlorite: A popular swimming pool disinfectant that is known as liquid chlorine that has a high pH and is 12% available chlorine content.

Sodium Thiosulfate: A chlorine neutralizer that is added to the pool when the chlorine is above 10 ppm.

Spa: A hydrotherapy pool that is typically kept between 99- and 104-degrees Fahrenheit.

Stabilized: These compounds do contain carbon and are NOT sensitive to UV light.

Stabilizer: A chemical additive used to prevent the UV rays from decomposing (eating up) the chlorine residual (or chlorine level).

Superchlorination: Introducing 10 to 15 ppm of FAC to a swimming pool in order to oxidize all the chloramines.

Test Kit: A device used to measure the chemical and mineral levels in a swimming pool.

Titration: A chemical testing procedure by which an indicator is added to a given test sample followed by the addition of a titrating solution that brings about a color change. The number of drops is used to calculate the amount of chemical.

Total Alkalinity: A chemical reading that represents the number of carbonates, bicarbonates, and hydroxides in a solution.

Total Available Chlorine: The total of the Free Available Chlorine and the Combined Available Chlorine in the water.

TDS (Total Dissolved Solids): The sum of all organic and inorganic materials dissolved in the water: including the following: minerals, salts, sweat, urine, etc.

Tri-Sodium phosphate: A filter cleaner (degreaser) should be used regularly to clean the oils, etc. out of the filter.

Turbidity: Cloudiness or lack of clearness in water that usually results from suspended particles in the water.

Turnover rate: The amount of time it takes all of the water in the pool to go through the filtration system and return to the pool basin.

Underdrain: The laterals at the bottom of a sand filter that allow the pool water to leave the filter tank.

Unstabilized Compounds: Compounds that do not contain carbon and are VERY sensitive to UV light. This means that when the sun comes out, they will dissipate (go away.)

Uranine Dye: A powder or liquid reagent used to check the circulation. It is put into a skimmer and will go through the system, coming out of the returns, showing the equal distribution of flow for pool circulation.

Vacuum Filter: Any pool filter where the pump follows the filter (effluent side) and pulls that water through the filter.

Valve Legend: A chart, illustration, or list that identifies the components of that filtration system. The valve legend should be posted in the pump room, easily visible, and clearly reflect the locations of all the pertinent valves and pipes and the color coding for each.

Vinyl Liner: A plastic membrane constructed of vinyl or vinyl compounds that act as a container for pool water.

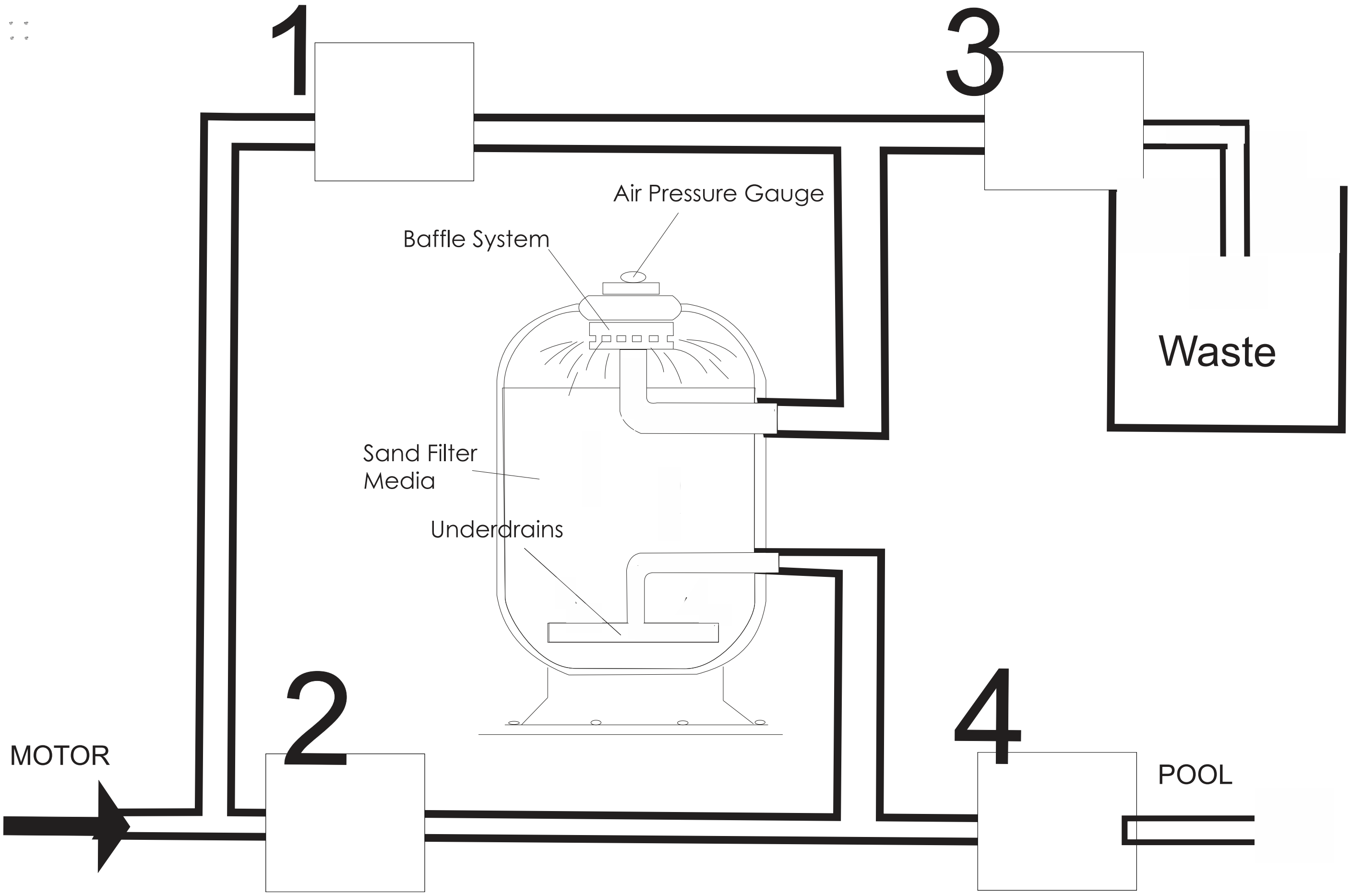
Weirs: Doors or flaps on the skimmer openings which prevent major debris from clogging the skimmers and thus allowing the skimmers to effectively pull the surface water into the skimmer lines. Weirs are crucial for proper operation of the skimmer and effective circulation. They are either spring-loaded or hinged.

Wet –Niche Lights: Lights that are located in "niches" within the pool basin. These lights must never be turned on unless they are in the water. Extreme care must be taken when changing the bulbs.

Winterizing: The procedure of preparing pools and spas for freezing weather by chemically treating the standing water plus protecting the pool, spa, and its equipment against freezing.

APPENDIX F

REVIEW SHEETS



	OPEN	CLOSED
Filter:	______	______
Backwash:	______	______
Drain:	______	______
Bypass Filtration (to prime):	______	______

Turnover Times		**Maximum Temperatures**	
Main Pool	____________	Main Pool	____________
Wading Pool	____________	Therapy Pool	____________
Spa	____________	Spa	____________

Fill in the chart with the range of each reading and the chemical name that raises and lowers each reading:

Chemical	Minimum	Maximum	Raise	Lower
Chlorine				
pH				
Total Alkalinity				
Calcium Hardness				
Cyanuric Acid				
Total Dissolved Solids	No Minimum		Not Applicable	

WORD BANK

USE THE FOLLOWING ANSWER TO FILL IN THE APPROPRIATE BLANK

Backwash	Free Available Chlorine	Gauges	Sodium Hypochlorite
Breakpoint	Filter Run	MSDS	Superchlorination
Chloramines	Flow Rate	pH	Total Dissolved Solids
Combined Chlorine	Flocculent	Priming the pump	Total Alkalinity
Cyanuric Acid	Hair and Lint Strainer	Phenol Red	Valves
DPD	Impeller	Sequestering Agent	
Effluent Line	Influent Lines	Return Water	

1. The point at which the chlorine is raised to 10 times the combined chlorine level and all of the chloramines are oxidized. ____
2. This is the other name for the return line. ____
3. The amount of water per minute that is returning back to the pool __________________________________
4. The measure of how acidic or basic the water is. ____
5. This stands for Material Safety Data Sheets and are required by OSHA (Occupational Safety and Health Administration). These sheets provide complete information on the chemical being used _______________
6. The instrument inside the motor that creates the vacuum pressure that pulls the water through the system. _________________________
7. The reverse of flow of water through the filter tanks in order to clean out the system. ____
8. These control the flow of water in system. Examples are gate, floating, ball and butterfly. _____________________________________
9. The chlorine that is available for disinfection in the water. _____________________________________
10. The phrase refers to the amount of time between backwashes. ___________________________________
11. This is the process that provides a system enough water to begin filtering prior to the pump being turned on.______________
12. Water that is going back to the pool through the return line. ____________________________________
13. It is a filter aid that connects with small particulate matter to make the filter more efficient. The most popular is Aluminate Sulfate (Alum). _______________________________________
14. Chlorine that has already connected with ammonia or nitrogen and is no longer useful for disinfection. High levels of these usually cause a strong odor and cloudy water. Also known as Combined Chlorine. ___________________________
15. Those lines that bring water into the system (Main Drain, Skimmer and Vacuum). ______________________________________
16. It is used to stabilize Chlorine against the effects of the suns UV light. ____
17. Ineffective chlorine (also known as Chloramines) which level is found by subtracting the free available chlorine from the total available chlorine. _______________________________________
18. Matter that is in the water that is unable to be reduced or eliminated with chemicals. ____________________________________
19. The reagent that is used to measure chlorine. ____
20. A chemical that is added to water which prevents staining by keeping metals and minerals in the water color free.____________________
21. This is the correct chemical name for liquid chlorine, and it has 12% available chlorine content. It will also cause the pH to go up when added. ____
22. This serves as protection for the motor by preventing large debris from damaging the impeller. It is always located before the motor. ____
23. The process of surpassing breakpoint by raising the free available chlorine level to at least 10 to 15 ppm. ___________________________
24. The buffering capacity of the water to maintain it current level of pH. Its definition is the amount of carbonates and bicarbonates in the water. .____
25. These are used to measure the pressure in the system. _______________________________________
26. The reagent that is used to measure pH. ____

MEASURING WATER BALANCE

Water Chemistry & the Saturation Index

Chapter Review Quiz

Place the correct letter of the right-hand column that is associated with the item in the left-hand column.

___ 1. pH	A. The reagent that is used to measure pH
___ 2. Phenol Red	B. The acceptable range for pH
___ 3. 7.0	C. The acceptable range for Calcium Hardness
___ 4. 7.5	D. The acceptable range of water balance
___ 5. 7.2 to 7.8	E. Mineral deposits on the walls or in the pipes
___ 6. 60 to 180	F. Material Safety Data Sheets
___ 7. 150 to 400	G. The number of carbonates and bicarbonates in H2O
___ 8. Total Alkalinity	H. The measure of how acidic or basic the water is
___ 9. Low Alkalinity	I. Causes pH to bounce uncontrollably
___ 10. Calcium Hardness	J. Amount of Calcium and Magnesium in water
___ 11. Total Dissolved Solids	K. Neutral pH
___ 12. MSDS	L. All matter that cannot be eliminated with chemicals
___ 13. Too high of Alkalinity, pH or Hardness	M. Causes of Scaling
___ 14. Scaling is	N. Acceptable range for total alkalinity
___ 15. Too low pH, Alkalinity or Hardness	O. The pH of the human eye
___ 16. -.3 to +.5	P. Causes of corrosion

Basic Pool Operation Information:

1. A registered Pool Operator must be present for the pool to be open.
2. Lifeguard to swimmer ratio cannot exceed a ratio of 50:1 (ATCS recommends 25:1)
3. Some of the factors that affect the number of guards required to safely monitor a facility are the following: number of guards on duty, number of swimmers in the water, the skill level of swimmers, shape of facility, temperature, and activity.
4. Pool readings in a main pool must be taken every 2 hours for Chlorine and pH. In a main pool, Total Alkalinity, Calcium Hardness, and Cyanuric Acid must be taken once per week. (Spas and Wading Pools have different requirements.)
5. Each pool must have a working phone for emergency calls, or the pool should not be opened. Cell phones are not acceptable.
6. The lifeguard must be located on the pool deck and watching the pool.
7. Pool certifications must be posted (PSPO, Lifeguard, & CPR certifications) must be posted in the guard room. The health department is not obligated and often will not accept copies of certifications.

11 REASONS FOR CLOSURE ACCORDING TO MONTGOMERY COUNTY, MD

When any of the following conditions are found to exist at any public pool, the pool permit must be suspended, and the pool closed until such time as the condition has been corrected and an inspection by the director has been made, or approval to reopen has been granted by the director:

1. A lifeguard is not on the pool deck of a general use pool, or a spa guard is not on the premises of a spa.
2. The main drain is not clearly visible from the nearest lifeguard chair or the furthest edge of the pool if the pool has no lifeguard chair.
3. The free chlorine, total bromine, pH, or cyanuric acid readings of the pool water are other than specified under Section II, B.1.
4. The recirculating equipment is not working properly for more than one hour.
5. The water level is below the skimmers in pools using this method of circulation.
6. The chemical disinfectant feeder has not been functional for a period of 24 hours, provided that pH, free chlorine, total bromine, or other approved disinfectant residuals are maintained in accordance with Section II, Water Quality.
7. The bathhouse drainage system is blocked sufficiently to render the bathhouse unusable; water is not available at sufficient pressure to operate the bathhouse, waste disposal systems are inoperable, unsanitary conditions exist, or the bathhouse is unusable for other health or safety reasons.
8. The director has been wrongfully denied permission to inspect the pool pursuant to Chapter 51 and these regulations.
9. A licensed Montgomery County pool operator is not in immediate control of the pool.
10. The director determines that an immediate hazard exists to the health or safety of the users of any pool.
11. At least one lifeguard currently certified in infant/child/adult CPR is not within the pool enclosure.

Chemical Safety Guidelines

These guidelines are steps you can follow in order to minimize your risk of being injured by potentially hazardous chemicals at your workplace.

-Always wear personal protective equipment, including gloves, goggles, an apron, and safety shoes. Unless exposed to bloodborne pathogens, used personal protective equipment may be discarded with the trash.

-All chemicals used for the pool should be stored in a well-ventilated area and inside clearly marked containers.

-Never mix chemicals with any substance other than water. Mixing a full-strength acid with chlorine will release toxic chlorine gas.

-When priming a chemical feeder, always point the hose away from your eyes and face.

-Never store chemicals in anything other than their original container.

-Take proper precautions and understand the hazards of working with pool chemicals.

-Wash hands before eating, drinking, smoking, and leaving the worksite.

All pools need chemicals to keep them sanitary and safe according to health department standards. Exercise extreme caution when working with chemicals. Chemicals must be used properly to ensure the safety of staff and patrons. Lifeguards must use their senses to detect hazards. Be aware of eye irritation, odors, visible clouds of dust or fumes, and leaks or spills.

MSDS (Material Safety Data Sheets) contains a wealth of information including product name, chemical ingredients, health hazards, personal protective equipment, safe exposure limits, spill/fire/emergency information, and handling/storage/disposal information.

Only certified pool operators are trained to handle chemicals. Therefore, staff not certified as a pool operator should at no time handle chemicals at the pool.

The use and storage of hazardous chemical products in the workplace can expose workers to a variety of physical and health hazards. It is your employer's responsibility to educate you on the chemicals used at your facility. It is your responsibility to make sure that your staff has been educated as well.

Adjusting Water Chemistry/Saturation Index

pH -The measure of how acidic or basic the water is.

The higher the pH, the less effective is the ability of the chlorine to

disinfect the pool. Phenol Red - It is used to measure pH.

7.0 is neutral pH. The pH of the human eye is around 7.5 pH should be maintained between 7.2 and 7.8

Alkalinity - The buffering capacity of the water to maintain it current level of pH. Total alkalinity is the number of carbonates and bicarbonates in the water.

pH bounce is from too low Total Alkalinity and is where the pH goes up and down uncontrollably.

Calcium Hardness Water needs calcium. If the calcium is not kept up, it will take calcium out of the pool shell. If it is too much, it will deposit the excess calcium and clog pipes.

Cyanuric Acid is used to stabilize the chlorine. It is not used in indoor pools. It fights the effect that UV light from the sun has on chlorine. The more cyanuric acid that is in the pool does not make it more effective. The operator should shoot for 40 to 50 ppm for maximum results.

Total Dissolved Solids - Matter that is in the water that is unable to be reduced or eliminated with chemicals.

MSDS - These stands for Material Safety Data Sheets and are required by OSHA (Occupational Safety and Health Administration). These sheets provide complete information on the chemical being used.

Sequestering Agent - A chemical that is added to water, which prevents staining by keeping metals and minerals in the water colorfree.

Too high of Alkalinity, pH or Hardness will cause scaling. (IF SOMETHING IS TOO HIGH THE ANSWER IS SCALING)

Scaling is calcium and other mineral deposits on the walls or in the pipes

Too low pH, Alkalinity, or Hardness is corrosive and can cause etching or short plaster life. (IF SOMETHING IS TOO LOW THE ANSWER IS CORROSIVE).

To add chemicals to the pool, mix chemical into a bucket of water and then pour into the pool. Each chemical should be done on at a time and should always be added to water.

Filtration

Turnover (the time it takes to circulate all the water in the pool through the filter)

Turnover Times

Main Pool:	6 hours
Wading Pool:	2 hours
Spa:	30 Minutes
Therapy:	4 hours

Influent Lines - Those lines that bring water into the system (Main Drain, Skimmer, and Vacuum).

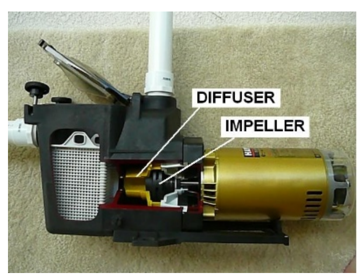
Skimmers are used to collect debris of the top of the water.

Weirs keep the debris in the skimmers.

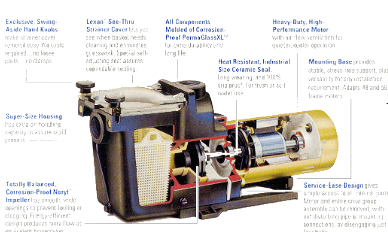
The main drain pulls the water and debris from the bottom of the pool. Less than 50% of the water can be pulled from the main drain into the filter system.

Valves - These control the flow of water in the system. Examples are gate, floating, ball, and butterfly.

Hair and Lint Strainer (Pot)- This serves as protection for the motor by preventing large debris from damaging the impeller. It is always located before or above the motor.



Impeller - The instrument inside the motor that creates the vacuum pressure that pulls the water through thesystem.



Priming the pump - This is the process that provides a system enough water to begin filtering prior to the pump being turned on.

Gauges - These are used to measure the pressure in the system. Pressure gauges measure in pounds per square inch (psi). When the influent and effluent gauges are more than 15 psi apart, the operator knows it is time to backwash.

The air bleeder valve is on top of the tank and releases air out of the filter tank.

Filter Tanks are used to clean the water. There are three major types of filters.

Sand Filter

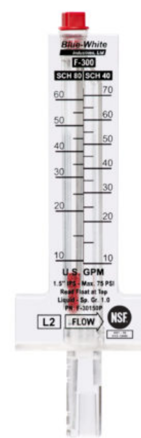
Cartridge Filter

DE Filter

Flocculent - The most popular flocculent Sodium Aluminate (Alum). It is a filter aid that connects with small particulate matter to make the filter more efficient.

Backwash - The reverse of the flow of water through the filter tanks to clean out the system. Filter

Run - The amount the "filter runs" between backwashes.



Flow Rate - The amount of water per minute that is returning back to the pool

The flow rate is measured in gallons per minute (GPM)

Return Water - Water that is going back to the pool through the return line.

Effluent Line - This is the other name for the return line.

Disinfection

Disinfection (the process of killing living microorganism and bacteria to prevent transmission of disease) Disinfection Levels

Main Pool	1.0	-	10.0 ppm
Wading Pool,	3.0	-	10.0 ppm
Spa and Therapy	4.0	-	10.0 ppm

Chlorine gas is heavier than air (therefore a ventilation fan should be close to the floor)
Chlorine gas lowers pH.
As precautions gas containers must be chained to the wall, a gas mask must be present, and a spray bottle of ammonia must be in the pump room to check for leaks.

Liquid Chlorine is also known as sodium hypochlorite. Sodium Hypochlorite (liquid chlorine) is only 12% ACC.
Most pools use sodium hypochlorite, and Sodium hypochlorite raise pH

Granular Chlorine or HTH is Calcium Hypochlorite and raises pH Shock is

Lithium Hypochlorite and raises pH/

Free Available Chlorine is the disinfectant that kills bacteria. It is the chlorine that is available for disinfection in the water.

DPD - It is used to measure chlorine.

FAC = DPD 1 & 2

TAC = DPD 1, 2, & 3

CAC = TAC - FAC

Combined chlorine is also known as chloramines
Chloramines - Chlorine that has already connected with ammonia or nitrogen and is no longer useful for disinfection. High levels of chloramines usually cause a strong odor and cloud water. Chloramines (combined chlorine) provides no disinfection

When combined chlorine reaches .4 ppm, the pool should be super chlorinated
Super chlorination takes the reading beyond breakpoint and gets rid of combined chlorine

Breakpoint - The point at which the chlorine is raised to 10 times the combined chlorine level and all of the chloramines are oxidized. (10xCAC)

Superchlorination - The process of surpassing breakpoint by raising the free available chlorine level to more 25 ppm. It is important to do when the water is cloudy.

Bromine is not as effective as Chlorine in normal conditions. However, it is not affected by heat and continues to disinfect after combining, making it great for spas.

All pools must have an automated system for delivering disinfectant to the water.

AQUATIC TRAINING & CONSULTING SERVICES

Aquatic Training & Consulting Service Pool Operator Review Sheet

> **"A Certified Pool Operator's main job is to prevent accidents and the transmission of disease in a safe pool environment."**

Check Your Chemicals

Chlorine and pH should be checked every two hours

Alkalinty, Hardness and Cyanuric should be checked each week

Suggested Pool Ranges

Chlorine (Main)	**2.0 to 5.0**
Chlorine (Spa)	**4.0 to 5.0**
pH	**7.2 to 7.8**
Total Alkalinity	**80 to 120**
Calcium Hardness	**200 to 350**
Cyanuric Acid	**30 to 50**
Total Dissolved Solids	**under 1500**

Chemicals - What Do They Do?

Muriatic Acid	⇨ Lowers pH and Alkalinity
Sodium Carbonate	⇨ Raises pH (known as Soda Ash)
Sodium Bicarbonate	⇨ Raises Alkalinity (known as Baking Soda)
Sodium Thiosulfate	⇨ Lowers Chlorine
Cyanuric Acid	⇨ Stabilizes Chlorine (use outdoors only)
Calcium Chloride	⇨ Raises Calcium Hardness
Sodium Hypochlorite	⇨ Raises Chlorine (known as liquid chlorine)
Calcium Hypochlorite	⇨ Raises Chlrorine (known as HTH)

12 Reasons for Pool Closure

- **No certified operator on duty.**
- **Lifeguard with current certifications not present.**
- **Chemicals are out of balance.**
- **Chemical feeders not operating for more than 24 hours.**
- **Filtration system not operating for more than 1 hour.**
- **Water is below the skimmers.**
- **Main drain is not easily visible.**
- **Health Inspector denied access to the facility.**
- **Bathrooms and/or drains not operational.**
- **Facility presents a danger to patrons.**
- **Flowrate is insufficient for adequate turnover.**
- **Phone is not operational.**

Langelier Saturation Index

Measures pH, Alkalinity, Hardness and Temperature!
An operator's facility may be within -0.3 or +0.5.

Thunder Closes Pools for 30 Minutes

Lightning Closes Pools for 30 Minutes

No Exceptions!

Water that is out of balance...
Too low is corrosive &
Too high produces scaling.

SAFETY

NEVER ADD WATER TO CHEMICALS - ALWAYS CHEMICALS TO WATER

NEVER MIX CHEMICALS TOGETHER

STORE CHEMICALS IN A COOL, DRY, WELL-VENITALATED AREA

NEVER STORE LIQUID CHEMICALS ON TOP OF SOLID CHEMICALS

ALWAYS WEAR PROTECTIVE GEAR WHEN HANDLING CHEMICALS

FLUSH EYES FOR 20 MINUTES IF CHEMICALS GET IN EYES

A Pool Must Have A Woking Phone In Order To Be Open!